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TAXONOMIC AND DISTRIBUTIONAL STUDIES OF MOSSES OF CENTRAL AND EASTERN PENNSYLVANIA

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Workers in the field of phytogeography and ecology of Bryophytes have been handicapped in recent years by the lack of up-to-date check lists and authentic distributional data concerning many moss species in states and other local areas. Because of this deficiency students of general ecology have generally disregarded the Bryophyte flora entirely or given it only slight attention. For these reasons, the problem of collecting mosses and studying their distribution and habitat preferences in Central and Eastern Pennsylvania seemed necessary and worth while.

In the historical sketch given below, it will be realized that Central and Northern Pennsylvania was, to all practical purposes an "unknown land" bryologically.

HISTORY OF BRYOLOGICAL STUDY IN PENNSYLVANIA

The study of Bryophytes has not been neglected in Pennsylvania, but most of the work has been confined to the southeastern and northeastern counties and the district around Pittsburgh.

The most significant early collecting and study of mosses was made by Muhlenberg in Lancaster County. Because of his correspondence with eminent botanists in Germany, England, France and Sweden, many species of mosses have "Lancaster County" or "Pennsylvania" as their type locality. Muhlenberg's "Index Flora Lancastriensis," published in the Transactions of the American Philosophical Society, includes a list of the Bryophytes of Lancaster County.

Thomas P. James, a druggist of Philadelphia and co-author with Leo Lesquereux of the "Manual of Mosses of North America," lived part of his life in Delaware County near Radnor and made large collections in the counties surrounding the city. The section on mosses in Darlington's "Flora Cestrica" was prepared by James. Part of his herbarium is in the collection of the Academy of Natural Sciences of Philadelphia and is in excellent condition. Very little information other than locations and dates was given, as was the case with most of the early collections.

Dr. Thomas Conrad Porter, author of the "Bryophyta and Pteridophyta of Pennsylvania," collected mosses in several localities. In 1853 he became Professor at Franklin and Marshall College in Lancaster and made collections in that and nearby counties. In 1866 he was appointed Professor of Natural Science at Lafayette College in Easton and while there made most extensive collections in Northampton and Monroe Counties. That part of his herbarium not destroyed by fire in the science building at Lafayette College was deposited in the collection of the Academy of Natural Sciences of Philadelphia.

Rev. Francis Wolle of Bethlehem, better known for his work in algae, collected Bryophytes in the northeastern counties and many of his specimens are in the Herbarium of the University of Pennsylvania. Much of this material is of little use in distributional studies because exact localities and dates are vague and even lacking in many cases.

Eugene A. Rau, also of Bethlehem, was a contemporary of Wolle and worked in the same territory. His collections are distributed in a number of herbaria, but the bulk of them is in the New York Botanical Garden. Distributional data are lacking in much of the material.

Dr. John K. Small and Dr. A. A. Heller, while students at Franklin and Marshall College, made many interesting Bryophyte collections in Lancaster, Lebanon and Dauphin Counties in the fall of 1888 and spring of 1889.

The formation of the Philadelphia Moss Chapter of the Sullivant Moss Society in February 1899 with Dr. A. F. K. Krout as President and Josephine B. Lowe as Secretary, stimulated anew the interest in mosses in this vicinity. Material collected and identified by this group in the environs of Philadelphia and in Berks and Monroe Counties is deposited in the Herbarium of the University of Pennsylvania and is well documented. It has been of great value in the present study.

Mr. George B. Kaiser, at one time Curator of the Sullivant Moss Society Herbarium, collected and studied the mosses around Philadelphia and many of his specimens are to be found in the two local herbaria.

Through the efforts of D. A. Burnett, the moss flora of McKean County is well known and specimens are widely distributed in herbaria. W. C. Barbour has done the same for the area around Sayre in Bradford County. Dr. O. E. Jennings has surveyed the moss flora of the western half of the state and published the "Manual of Mosses of Western Pennsylvania" in 1913.

In 1933 Miss Grace Tees in partial fulfilment for a Master's Degree at the University of Pennsylvania, prepared a check list of mosses of the Philadelphia area including all the territory in New Jersey, Pennsylvania, Delaware and Maryland within a 100 mile radius of the city. This manuscript is in the Library of the University of Pennsylvania and has proved valuable in completing the present study.

A glance at the map of Pennsylvania will show immediately that up to the present writing the central and northern portions of the state have been

bryologically unknown. With this in mind the author has concentrated his collecting in these areas, visiting 44 of the 67 counties of the state. Acknowledgment should be made to the following for their collecting of Bryophytes while doing field-work with other groups of plants: Robert L. Schaeffer, Jr. in Northampton County; Harold W. Pretz in Lehigh County; Hans Wilkens in Berks County, Paul R. Wagner in Schuylkill County. Others responsible for 20 or more collections utilized in this study are:

Adams, J. W.
Austin, C. F.
Barbour, W. D.
Bartram, E. B.
Beals, A. T.
Benner, W. M.
Best, G. N.
Britton, E. G.
Browne, C. H.
Borden, L. P.
Burnett, D. A.
Carter, J. J.
Cresson, E. T., Jr.
Devlin, Joseph
Dix, W. L.
Eby, Mrs. A. F.
Erisman, Mrs. Nellie
Fisher, H. L.
Fogg, John M., Jr.
Gadsby, E. B.
Garber, A. P.
Githens, T. S.
Harper, J. S.
Haydock, W. E.
Henry, H. K.
James, T. P.
Jennings, O. E.
Kaiser, G. B.
Krout, A. F. K.
Lippincott, C. D.
Leeds, A. N.
Lisi, A. G.
Long, Bayard
Lowe, J. D.
Macfarlane, J. M.
McMinn, J. M.
Muhlenberg, G. H. E.
Platt, R. B.
Pohl, R. W.
Porter, T. C.
Pretz, Harold W.
Proctor, G. R.
Rau, E. A.
Roberts, C. M.
Ruth, J. A.
Schaeffer, R. L., Jr.
Small, J. K.
Spencer, Mrs. Thomas
Taylor, W. R.
Tees, Grace M.
True, Rodney H.
Wagner, Paul R.
Wahl, H. A.
Wherry, E. T.
Wilkens, Hans
Windle, F.
Williams, Mrs. M.
Wolle, Francis

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COLLECTING PROCEDURE

In making collections for this study, individual species or groups of species growing together were placed in individual bags. Exact information regarding substrate, type of cover and habitat was recorded. During the first part of the study the pH of the soil was taken by the colorimetric method using a LaMotte Soil Testing Kit. Later, soil samples were collected and readings made on a Leeds and Northrup pH meter to check the previous results. Only when sufficient readings have been taken is this information included in the text. Exact locations and elevations of collecting spots were made with the aid of United States Topographic Maps. Associated species of plants, especially the Bryophytes, were noted in the field or later during the laboratory examination. Whenever the material examined was fertile, the condition of the antheridia and archegonia or the sporophyte was noted.

The method of recording the distribution of species by counties is that outlined by Fogg (1947) in his study of the methods applied to a state flora survey. In addition to the county records for each species, a summarizing form was kept, tabulating information from each individual specimen concerning habitat, substrate, pH range, elevation, associates or succession and reproduction. From these master records, the data for each individual species was easily organized.

ECOLOGICAL STUDIES

In attempting to explain the distribution of mosses in Pennsylvania, all the ecological factors usually so important in influencing Phanerogamic distribution, such as Physiographic Provinces, glaciation, macroclimate, geographic relationships and forest types, have been investigated and do not provide an adequate explanation. But the factors controlling the microhabitat of the mosses, that is the temperature, moisture, light, edaphic and biotic conditions of the particular site, appear to be more important and offer the most reasonable explanation of distribution.

PHYSIOGRAPHIC PROVINCES

The area under investigation covers 49 central and eastern counties of the state, extending to the western boundaries of McKean, Elk, Clearfield, Cambria and Somerset Counties.

The topography of this portion of Pennsylvania is divided into six major provinces (Fenneman, 1938), traversing the state in a northeasterly to southwesterly direction.

The Coastal Plain is confined to the extreme southeastern corner of the state and is limited on the west side by the Fall Line. The City of Philadelphia and its suburbs occupy much of this narrow belt, thus obscuring its original character.

Bounding this area on the north and extending from the Delaware River to the Mason and Dixon Line is the Piedmont Province. It consists of

wide fertile limestone valleys, rolling hills of crystalline rock and the Triassic lowlands along the northern boundary.

The Blue Ridge Province extends northeastward into the state through parts of Adams, Franklin, Cumberland and York Counties, nearly to the Susquehanna River where it has its terminus. The Reading Prong of the New England Province extends into Pennsylvania in a southwesterly direction from the Delaware River through parts of Northampton, Carbon and Berks Counties. These areas consist of narrow belts of crystalline ridges forming the southern boundary of the "Great Valley" of the Ridge and Valley Province. In the region between them, the Ridge and Valley Province immediately adjoins the Triassic lowlands of the Piedmont Province, i.e., between the Schuylkill River and a point 10 miles west of the Susquehanna River.

The southern portion of the Ridge and Valley Province is known as the "Great Valley" and is underlain by Cambrian and Ordovician limestones and shales; it averages 10 to 20 miles in width. It is known under the local names of Lebanon Valley and Cumberland Valley; its southern extension into Virginia is the famous Shenandoah Valley. The northern portion of the Province is a succession of eroded valleys and hard, resistant, even-crested ridges of sandstones and shales. Their elevation increases westward from 1300 to 1600 feet.

The Allegheny Mountain section is characterized by high ridges, reaching an elevation of 3200 feet in southern Somerset County. These mountains are plateau-like and are separated by valleys which are, according to Fenneman (1938), deeply dissected plateaus and not lowlands. These ridges form the front escarpment of the Appalachian Plateau Province.

From elevations as high as 2000 feet, the Plateau Province decreases gradually toward the west and merges finally with the Central Lowlands. It is characterized by broad plateau areas deeply cut by narrow stream valleys. Only the northeastern and northwestern portions of this plateau were covered by the Wisconsin glaciation (Fig. 1).

These physiographic provinces are of minor importance in the distribution of mosses within the state. A few boreal species, such as *Mnium cinclidioides* and *Brachythecium Starkei*, have not been found to occur outside of glaciated territory up to the present writing. Two species of *Dicranum* have been collected from the Ridge and Valley Province westward, but there are no species confined to any one Province. The relatively slight range of elevation in Pennsylvania as compared to that farther north and south is probably a factor to be considered. The distribution of mosses is more closely associated with microclimates, as will be shown subsequently.

MACROCLIMATE

The average annual precipitation ranges from 36 inches in the southern part of the Ridge and Valley Province, Bedford and Fulton Counties, and along the northern boundary in Bradford, Tioga and Potter Counties to

48 or 50 inches in Somerset County, where the highest elevations of the state are found. The rainfall for the eastern half of the state averages between 40 and 46 inches, with the highest precipitation in the southeastern corner. With abundant rainfall, well distributed throughout the year, mosses are common and abundant in the state. The individual species are restricted in their distribution by the evaporation rate of the particular site.

The temperature range in the state is not extreme. The average January temperatures are low at 22 degrees F. in the northern and central counties and 32 degrees F. in the counties of the southwestern and southeastern corners respectively. The average July temperatures vary from 66 degrees to 70 degrees F. in the northern and central part of the state to 74 degrees and 76 degrees F. in southwestern and southeastern Pennsylvania. The

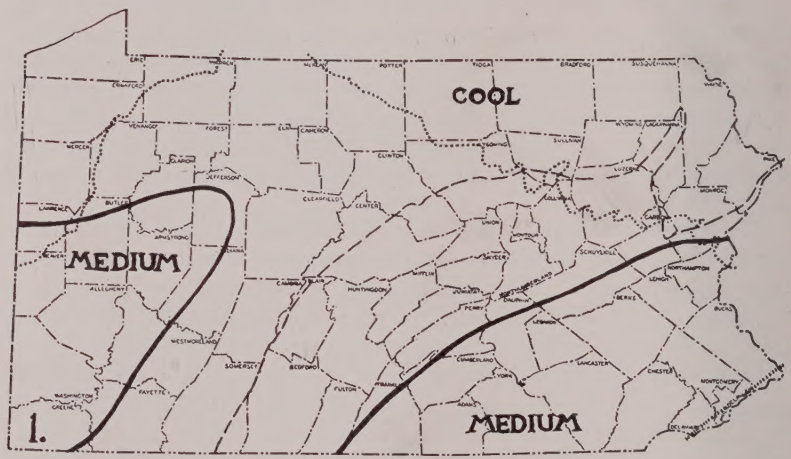


Fig. 1. Climatic zones in Pennsylvania. (Adapted from Livingston and Shreve).

lower temperature area corresponds to the "cool" area of Livingston and Shreve (1921) and the higher temperature area to their "medium" (Fig. 1).

Some species of mosses prove to be more abundant in one or the other temperature belt, but are not sharply delimited. This can be accounted for by the fact that mosses are influenced by the microclimate of their immediate habitat, rather than by the macroclimate of the meteorologist (Richards 1932).

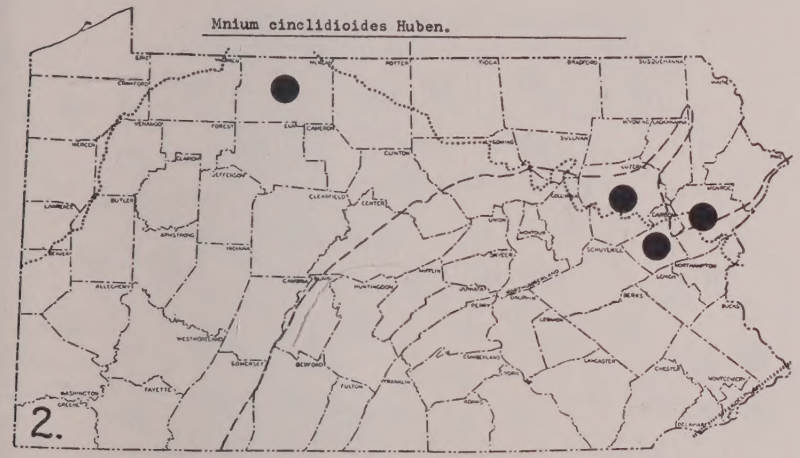
GEOGRAPHIC RELATIONSHIPS

Utilizing the geographic distribution for mosses presented by Sharp (1939) as a basis for relationships, the flora of Pennsylvania shows four geographic affinities.

First is a group of mosses of boreal affinities, circumpolar in their distribution, and reaching their maximum development in the far north. They

reach their southern limits in Pennsylvania and occur in the northern counties, chiefly in glaciated territory (Fig. 2 and 3).

Brachythecium Starkei
B. velutinum
Climacium dendroides
Dicranella rufescens
D. rugosum
Mnium cinclidioides
Polytrichum formosum
P. gracile
P. juniperinum var. *alpestre*
Thuidium abietinum



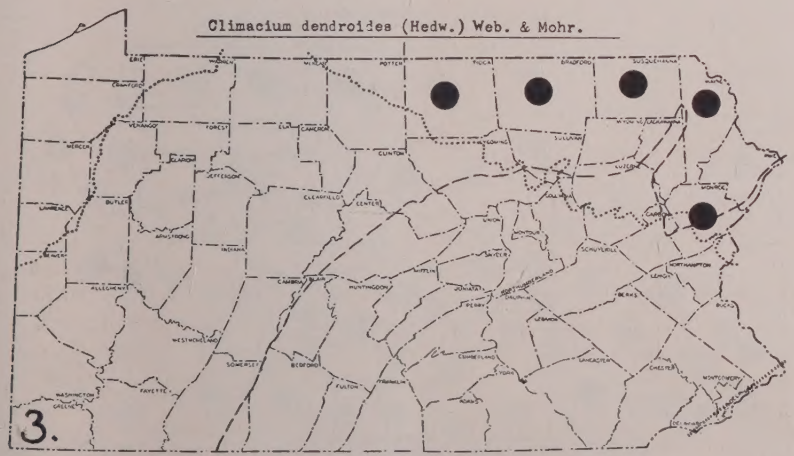
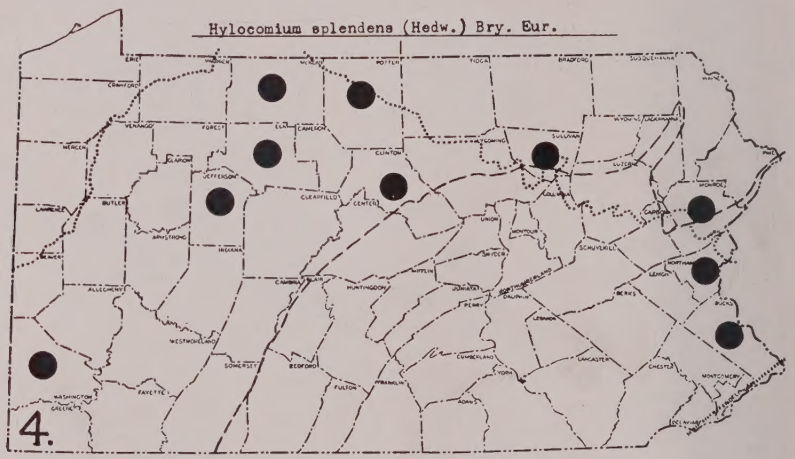


Fig. 2. Range of *Mnium cinclidioides* Huben. An example of mosses with Arctic affinities some of which reach their southern limits in the state.

Fig. 3. Range of *Climacium dendroides* (Hedw.) Web. & Mohr. An example showing range of a species with Arctic affinities.

Secondly, there are the moss societies which show relationship with those of the spruce-fir forest and entering Pennsylvania all along the northern boundary, funneling down the mountain chain through central Pennsylvania to the southern boundary and on into the Southern Appalachian Mountain system of Tennessee and North Carolina. Their distribution corresponds generally to the "cool" climatic zone of Livingston and Shreve (Fig. 1). They are found growing in the cool ravines and bottoms



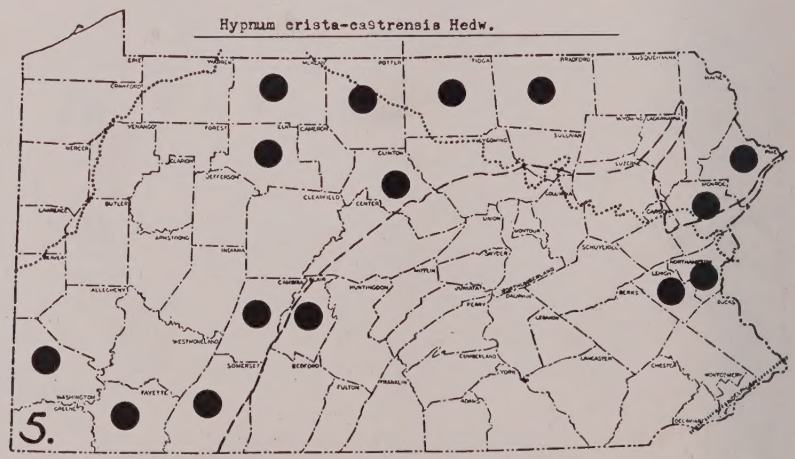
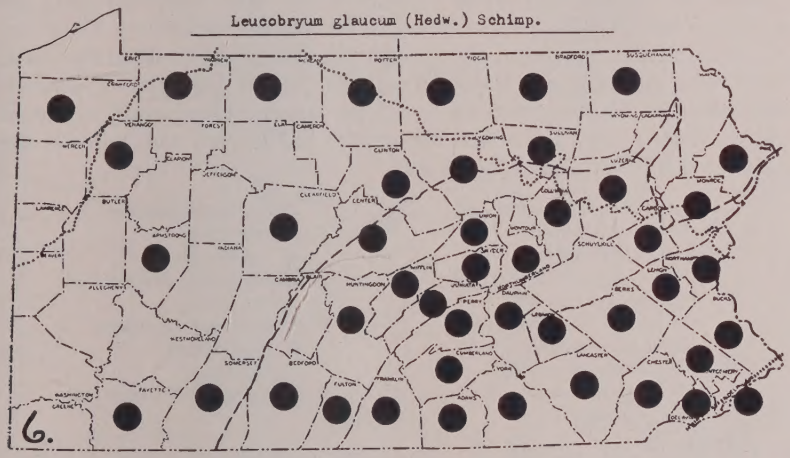


Fig. 4. Range of *Hylocomium splendens* (Hedw.) Bry. Eur. An example of a species showing relationship with the moss societies of the spruce-fir forests. Usually confined to the "cool" area of Livingston & Shreve.

Fig. 5. Range of *Hypnum crista-castrensis* Hedw. in Pennsylvania. Another example of distribution in the "cool" area of Livingston & Shreve.

occupied by the Eastern Hemlock Forest Formation of Nichols (1935). The fact that this type of microclimatic and forest conditions occur in parts of the state outside the "cool" zone, accounts for the occurrence of many species of mosses of this group in counties far removed from their normal range. The Wissahickon ravine in Philadelphia County and the hemlock ravines along the York County shore of the Susquehanna River are examples (Fig. 4 and 5).



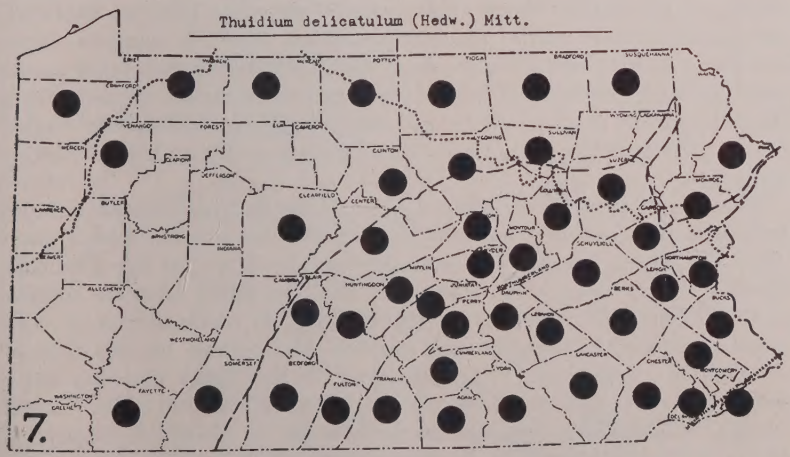


Fig. 6. Range of *Leucobryum glaucum* (Hedw.) Schimp. A widespread species and typical of the deciduous forests.

Fig. 7. Range of *Thuidium delicatulum* (Hedw.) Mitt. Another widespread species of the more mesic deciduous forests.

Anomodon Rugelii
Calliergonella Schreberi
Cirriphyllum piliferum
Dichodontium pellucidum
Dicranum Bonjeani
D. flagellare
Hylocomnium brevirostre
H. splendens
H. umbratum
Hypnum crista-castrensis
Mnium punctatum var. *elatum*
Oreoweisia serrulata
Plagiothecium Mullerianum

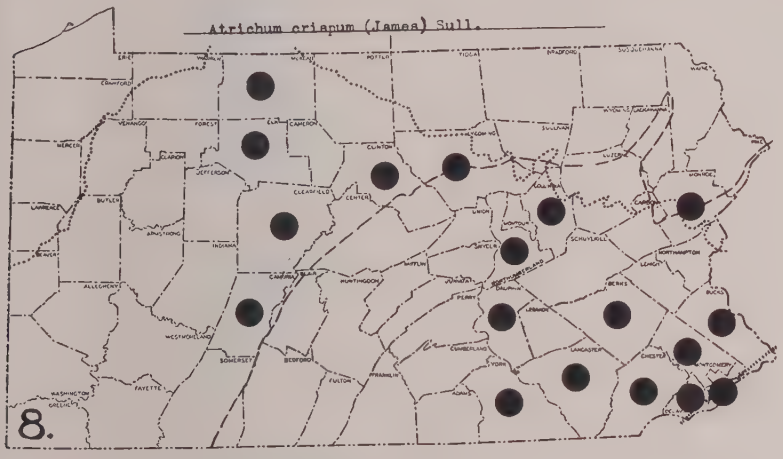
The third group of mosses are those that are widespread and occur in suitable habitats in most of the counties of the state. Lack of records for a county may usually be attributed to insufficient collecting. These are the characteristic species of the mesophytic deciduous forests of the state, principally the more xeric second-growth oak-hickory segregate. Communities belonging to this group are found on the sandstone-capped mountain ridges, their wooded slopes and the isolated oak-hickory woodlands of the cultivated fertile valleys (Fig. 6 and 7).

Anomodon attenuatus
Atrichum Macmillani
Ceratodon purpureus
Dicranella heteromalla var. *orthocarpa*
Dicranum scoparium
Entodon seductrix
Funaria hygrometrica
Hypnum imponens
H. curvifolium
Leucobryum glaucum
Mnium affine
M. cuspidatum
Plagithecium denticulatum
Pohlia nutans
Polytrichum commune
P. juniperinum
P. ohioense
Thuidium delicatulum

The fourth and smallest group in the Pennsylvania flora is that characteristic of the Coastal Plain. This group is separable into two elements, one including those species which migrated out from the Southern Appalachians onto the Coastal Plain (Sharp, 1939), extending their range northward to Massachusetts and beyond; and another including species having their metropolis in the Tropics and extending into southeastern United States and north along the coast, in many cases as far as Long Island or New Jersey.

The first element of the Coastal Plain group in Pennsylvania includes such species as *Fontinalis Sullivantii, Mnium hornum* and *Atrichum crispum* (Fig. 8 and 9), which grow commonly on the shores of the Piedmont rivers and their tributaries, where they find the sandy alluvium similiar to that of the soil of the Coastal Plain habitat on which they occur with greater frequency. There are two possible explanations for this type of distribution. Either they originally grew in the sandy alluvium along mountain brooks and moved into the more favorable habitat of the Coastal Plain after it emerged from the sea as indicated by Sharp (1939) as well as from evidence collected by Jennings (1945) which indicates the presence of *Mnium hornum* all through the Appalachian Plateau. Or, migrating northward along the Coastal Plain after its emergence, these mosses found the alluvial deposits on the banks of streams a suitable habitat and thus moved up the rivers and streams into the mountain and plateau regions.

Leucobryum albidum, *Pogonatum brachyphyllum*, *Thuidium minutulum* and *T. virginianum* (Fig. 10 and 11), examples of the second class of Coastal Plain species, enter the state in the counties of the southeastern corner and in Fayette County in the southwestern corner. This type of distribution is similar to that of a number of phanerogams found most frequently on the Coastal Plain which also extends up the Mississippi Embayment into western Pennsylvania. It will also be noted that this group is confined to the "medium" climatic zone of Livingston and Shreve (Fig. 1.).



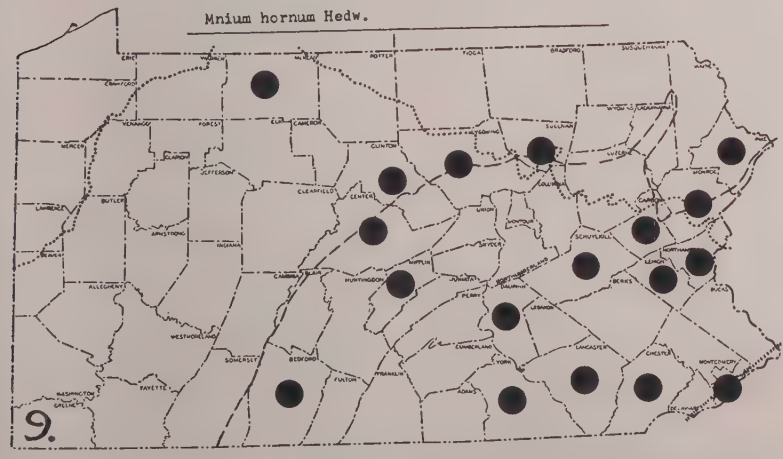
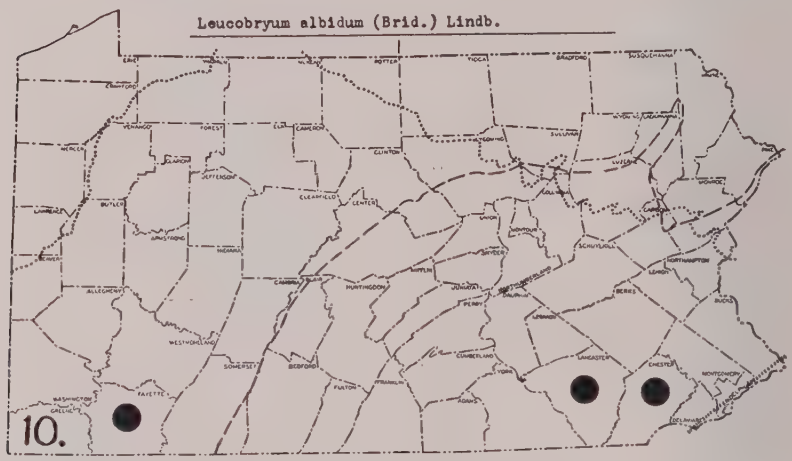


Fig. 8. Range of *Atrichum crispum* (James) Sull. A Coastal Plain species that has migrated northward from the southern Appalachians.

Fig. 9. Range of *Mnium hornum*. Another example of a Coastal Plain species.

NATURAL VEGETATION

In order to show relationship between moss distribution and forest cover it is first necessary to decide upon an accepted ecological classification of forest types. Illick (1928) has divided the forest vegetation of Pennsylvania into nine types, many of which grade into one another. These distinctions are finer than is required for the present purpose. Since Nichols' (1935) classification is simpler and more appropriate, I have chosen to



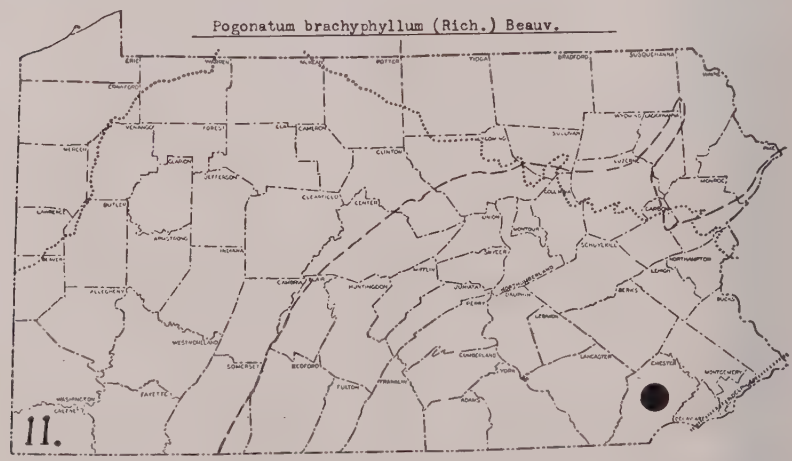


Fig. 10. Range of *Leucobryum albidum* (Brid.) Lindb. A southern Coastal Plain species extending north to southern Pennsylvania. Related to tropical species.

Fig. 11. Range of *Pogonatum brachyphyllum* (Rich.) Beauv. A southern Coastal Plain species extending north to Pennsylvania.

utilize it for this study. Thus Central and Eastern Pennsylvania lie in part of two formations, the Eastern Hemlock Forest of Nichols and the Eastern Deciduous Forest of Sargent (Nichols, 1935).

EASTERN HEMLOCK FOREST

The Eastern Hemlock Forest is a convenient name used by Nichols for a climax that could be more appropriately called "eastern hemlock-white pine-northern hardwood region." It corresponds roughly with the "Northern Pine Belt" of Sargent and the "Lake Forests" of Weaver and Clements. The more characteristic species involved are *Tsuga canadensis*, *Acer saccharum*, *Fagus grandifolia*, *Betula lutea*, *Pinus strobus*, *Tilia glabra*, *Ulmus americana*, *Fraxinus americana*, *Quercus borealis*, *Prunus serotina*, *Picea rubra*, *Abies balsamea*, *Picea glauca*, *Acer rubrum* and *Pinus resinosa*. The moss and liverwort flora of this formation is reported by Nichols as being very extensive both in quantity and number of species. The evidence from collections made in this forest area bears out this conclusion for Pennsylvania.

The characteristic species of the Hemlock Forest constitute the cover of the major portion of the forested area in the northern counties and in suitable habitats down the "cool" funnel of the central mountainous section. Tongues of this forest are also found on north-facing slopes and in deep cool ravines in many other portions of the state. The composition of this forest, as to species and their relative abundance, is observed to vary both in different parts of the region and locally so that it can be separated into "segregates" in which one group or another of tree species dominate.

In the high, drier portions of this forest, where the birch-beech-maple segregate predominates, the moss species which commonly carpet the soil are:

Atrichum Macmillani
Brachythecium spp.
Dicranella heteromalla
Dicranum Bonjeani
D. rugosum
D. scoparium
Eurhynchium spp.
Leucobryum glaucum
Mnium affine
M. cuspidatum
Plagiothecium spp.
Polytrichum commune
P. juniperinum
P. ohioense
Thuidium delicatulum

In the same forest segregate on slopes and in depressions where conditions are more mesic, species of mosses that require slightly more moisture are found growing with the above named species.

Amblystegium spp.
Bartramia pomiformis
Fissidens adiantoides
Hypnum imponens
H. pratense
Mnium orthorhynchum

Where sandstone rocks are exposed, but shaded by the forest cover, and soil and humus has accumulated, *Dicranum fulvum* finds a desirable habitat.

The corticolous flora of the Eastern Hemlock Forest is sparse. Several

species occur occasionally on the lower and more moist portion of the tree trunks, but only *Thelia asprella* is common and universally present.

Dead logs and stumps are common, in all stages of decay. Where the environmental conditions are conducive to growth, one finds these logs and stumps more or less covered with mosses and liverworts. The dominant species on such subtrates are:

Brotherella recurvans
Dicranum flagellare
D. scoparium
Heterophyllium Haldanianum
Hypnum imponens
Mnium cinclidioides
Tetraphis pellucida

In the cool ravines and bottoms, where hemlock is the dominant species of tree, occurs the *Hylocomium* union of moss species approaching that characteristic of the northern spruce-fir forests (Sharp, 1939). The low temperature, high humidity and deeper shade of such a habitat seems to favor their lush growth. The species commonly present are:

Atrichum undulatum
Brachythecium salebrosum
Calliergonella Schreberi
Climacium americanum
C. dendroides
Dicranum scoparium
Drepanocladus uncinatus
Hylocomnium brevirostra
H. splendens
Hypnum crista-castrensis
Mnium affine
M. longirostrum
M. punctatum var. *elatum*
Rhodobryum roseum
Sphagnum spp.
Thuidium delicatulum

On rocks, exposed and submerged, in the cold streams that flow through these glens and ravines, are growing semi-aquatic and aquatic species of mosses. Those usually present are:

Eurhynchium rusciforme
E. strigosum var. *robustum*
Fontinalis antipyretica var. *gigantea*
F. dalecarlica
Hygroamblystegium fluviatile
Pohlia nutans
Rhacomitrium aciculare

EASTERN DECIDUOUS FOREST

The Eastern Deciduous Forest is highly complex in its structure and varies greatly from place to place. Prominent species in this climax are *Quercus* spp., *Hicoria* spp., formerly *Castanea dentata*, *Liriodendron tulipifera*, *Fagus grandifolia*, *Acer saccharum*, *Fraxinus americana*, *Prunus serotina*, *Tilia* spp., *Betula lenta*, *Aesculus octandra*, *Magnolia acuminata* and *Juglans nigra*. The trees in this forest climax tend to be large and long-lived, the forest canopy is usually several storied with one or more layers of small trees and shrubs. According to the writer's observations, this forest type tends to be more xeric than the Hemlock Formation, especially in the area of second and third growth. The Deciduous Forest, through its varied forest types, orginally covered the remainder of the state treated in this discussion. Much of the area formerly occupied by this formation is now devoted to agriculture or industrial and urban developments, thus completely eliminating the woodland.

Mosses and liverworts tend to be quantitatively less abundant here than in the Hemlock Forest. Nichols (1935) holds that their growth is checked by the accumulation of leaves and debris which covers the forest floor in autumn. I believe, however, that repeated disturbance of these areas by lumbering and fires, as well as the existence of relatively xeric and acid conditions, are additional factors that must be considered.

In the dry uplands of the oak and hickory segregate, widely scattered patches or cushions of mosses occur. They grow on the acid soil and humus, frequently at the bases of trees or rocks. The following species are most frequent in such habitats:

Atrichum Macmillani
Aulacomnium heterostichum
Bartramia pomiformis
Cirriphyllum Boscii
Dicranella heteromalla var. *orthocarpa*
Dicranum scoparium
Diphyscium foliosum
Ditrichum pallidum
Eurhynchium serrulatum
Hypnum imponens
Leucobryum glaucum
Mnium affine
M. cuspidatum
Plagiothecium denticulatum
Polytrichum commune
P. ohioense
Thuidium delicatulum
T. virginianum

On the top of the sandstone ridges in the scrub-oak forest, *Polytrichum piliferum* occurs along with the more xeric species listed above.

The exposed rock surfaces in the oak-hickory segregate support a moss flora, which in time, accumulates fine soil and humus. These prepare the substrate for the invasion of mesic species of mosses. Those commonly found in this type of habitat are:

Anomodon rostratus
Dicranum fulvum
D. fuscescens
Grimmia pilifera
Hedwigia ciliata

Decaying logs and stumps support a distinctive moss flora. The species universally present are:

Dicranum scoparium
D. flagellare
Hypnum imponens

In stream valleys on the alluvial soil where the maple-tulip-oak segregate predominates, another group of moss species are common:

Amblystegium spp.
Atrichum crispum
A. undulatum
Aulacomnium palustre
Brachythecium rivulare
Eurhynchium rusciforme
Fissidens taxifolius
Heterophyllium Haldanianum
Mnium affine
M. hornum
M. punctatum
Pohlia nutans
P. Wahlenbergii
Thuidium delicatulum

Rock outcroppings along the shores of these streams and submerged rocks in the streams serve as the substrate for the following species:

Fontinalis novae-angliae
Grimmia alpicola var. *rivularis*
Hygroamblystegium fluviatile
Rhacomitrium aciculare

Corticolous mosses are even less abundant than in the Hemlock Forest, but scattered growths do occur in more humid situations. The following are the common species:

Fissidens subbasilaris
Leskea gracilescens
L. obscure
Platygyrium repens
Thelia asprella

On eroded banks and newly made cuts along roads through the deciduous forest, the bare soil is colonized by a typical moss flora, including:

Atrichum Macmillani
Dicranella heteromalla
Ditrichum pusillum
Philonotis fontana (in wet ditches)
Pogonatum pensilvanicum
Polytrichum juniperinum
P. ohioense

Where former cultivated fields have been allowed to lie fallow for a number of years, a growth of weeds and shrubs starts the ecological succession back to the forest climax. Here a distinct group of mosses are found covering the soil at the base of the weeds and shrubs or in open exposed situations. They are principally the following species:

Ceratodon purpureus
Eurhynchium serrulatum
Funaria hygrometrica
Leucobryum glaucum
Mnium cuspidatum
Physcomitrium turbinatum
Polytrichum juniperinum
P. commune var. *perigonale*

In some parts of the area covered by the Deciduous Forest, limestone is the underlying rock. When this and other calcareous rock are exposed or just under the surface and covered by acid humus, the following mosses are common and show vigorous growth:

Amblystegium spp.
Anomodon attenuatus
A. minor
A. rostratus
Brachythecium spp.
Bryum argenteum
Cirriphyllum Boscii
Climacium americanum
Fissidens adiantoides
Orthotrichum strangulatum
Rhodobryum roseum
Thuidium recognitum

Besides the larger ecological formations discussed above, there are two distinct edaphic climaxes within the state that should be mentioned, the serpentine barrens of Delaware, Chester and Lancaster Counties and the shale bluffs and hillsides found on south-facing slopes of Brailler, Chemung and other shales in Bedford and Fulton Counties.

The serpentine barrens, from all available evidence, were never covered with forests, but were natural grassland. Their phanerogamic flora is quite unique and contains a few endemic species. To the present writing no endemic species of mosses have been found there, but those commonly occurring on these serpentine outcroppings are:

Anomodon attenuatus
A. rostratus
Aphanorhegma serratum
Bartramia pomiformis
Brachythecium oxycladon
Cirriphyllum Boscii
Climacium americanum
Dicranum rugosum
(Lancaster Co.)
Eurhynchium serrulatum
Grimmia pilifera (on rocks)
Hedwigia ciliata (on rocks)
Plagiothecium denticulatum
Polytrichum ohioense
Thuidium delicatulum
Tortella humilis (on log)
Weisia viridula

The shale bluffs and hillsides are more wooded in the northern parts of Bedford and Fulton Counties and pass gradually into the shale barrens proper, which extend southward in the Ridge and Valley Province from the southern part of Bedford County to southwest Virginia. They are covered with a sparse stand of oak, juniper and scrub pine, with a scattered growth of shrubs and herbs. The soil consists of large and small flaky particles of shale with little humus. The mosses listed below, which occur on these areas, are very similar to those found on the tops of the sandstone-capped ridges throughout the state:

Anomodon attenuatus
A. rostratus (at base of the bluffs)
Atrichum Macmillani
Aulacomnium heterostichum (more wooded slopes)
Bartramia pomiformis (more wooded slopes)
Dicranum scoparium
D. spurium
Ditrichum pallidum
Grimmia apocarpa (on rocks)
G. pilifera (on rocks)
Hedwigia ciliata (on rocks)
Leskea gracilescens (on juniper trees)
Leucobryum glaucum
Orthotrichum strangulatum (on rocks)
Platygyrium repens (bark at bases of trees)
Polytrichum juniperinum
P. piliferum
Thelia Lescurii (on shaley soil)
Thuidium delicatulum (shaded areas)
T. virginianum (more exposed spots)
Tortella humilis

Many species of *Cladonia* are associated with these mosses, commonest being *Cladonia verticillata* and *C. rangiferina*. *Cetraria islandica* occurs in the bare exposed areas.

HABITAT AND ENVIRONMENTAL FACTORS

In the local distribution of mosses, it is evident from observations made in the field and the study of distributional data, that factors other than topography, macroclimate and vegetational cover are involved, and are indeed more important. These factors are the microclimatic, edaphic and biotic conditions of the particular growing site of the individual moss plant.

The microclimate is determined by the light, temperature and humidity of the relatively small area in which the plant grows. Fluctuations of these conditions are caused by the slope of the soil, exposure and minor irregularities in the surface (Braun-Blanquet, 1932). The slight variation of

any one of these features causes a marked change in the moss flora within a slight radius at a single locality.

Because of the interaction of the conditions of light, temperature and humidity, it is difficult to determine the effects of each of them individually on the different species of mosses. An increase in the amount of light brings with it a rise in temperature and the more rapid evaporation of moisture (Richards, 1932). Only with controlled conditions, where temperature and moisture can be kept constant, would it be possible to determine the true relationship of the light factor to the growth of mosses.

Mosses seem to be generally more shade-tolerant than higher plants. There are a greater number of species as well as more individual plants or cushions in shaded areas than in bright light. It is difficult to say whether they are just tolerant of shade in order to escape competition or actually grow best in a low light intensity. On the other hand there are some species of mosses growing on rocks and barrens which withstand high light intensities. Most of these are relatively dark in color, blackish or reddish-brown, presumably to protect them from the high light intensity. Species which might invade such territory may be excluded because of the high temperature and moisture deficit, rather than the fact that they cannot tolerate strong illumination. The *Hylocomium* union described above always occurs in deep shade. Sharp (1939) tells of its disappearance whenever trees are cut or blown down. Light is admitted, raising the temperature and increasing the rate of evaporation, thus making the habitat unsuitable for this union.

Some species of *Polytrichum* grow in exposed positions. *Polytrichum piliferum* is found almost exclusively in the sun on sterile barrens or sandy mountain tops. *P. commune* and *juniperinum* flourish more frequently along sunny roadsides, covering large areas in old fields and open sand pits. Because of their growth in huge cushions it is possible they can retain a great amount of moisture by capillarity and thus withstand the drying effects of the higher temperature of an exposed situation.

In dealing with temperature we do not know if the limiting factor is the mean annual, absolute maximum or minimum, or average daily maximum or minimum (Richards, 1932). We do know, however, that the temperature near the soil surface shows greater variation than the temperature 5 to 10 cm. above the ground where the air movement tends to equalize it (Braun-Blanquet, 1932). The temperature of the substrate itself varies, particularly with the exposure and direction of slope. It has been found however that moss cushions and tufts usually maintain a temperature slightly higher than the surrounding air and the substrate upon which they grow (Richards, 1932).

There is no experimental evidence available as to the upper limits of temperature at which mosses will grow and survive. Sharp (1939) gives the example of Hedwigia growing on exposed rocks in eastern Tennessee, withstanding a summer temperature of 50 degrees C. and a winter temperature of −34 degrees C. Observations made in the field while collecting

have not been sufficient to justify final conclusions as to the effect of temperature on the distribution of Pennsylvania mosses. What appears to be the result of low or high temperature, may be caused by the light or humidity factors.

Mosses vary widely in their relationship to moisture. They range from species that are exclusively aquatic to those that live in the extreme xeric conditions found on bare, exposed rock surfaces.

Terrestrial and epiphytic mosses are sensitive to the saturation deficit, wind velocity and other factors affecting the rate of evaporation. However, their ability to absorb atmospheric moisture and retain it within the tuft or cushion is not only important in continuing the metabolism of the plant, but may frequently result in changing the habitat (Richards, 1932). Stream banks, humid glens and ravines, depressions or any other irregularity of the ground surface that aids in the retention of moisture are abundantly covered with a moss flora rich in species and quantity.

Many studies have been made of the water-holding ability of the bark of various trees and its effect on the epiphytic species present. It has generally been concluded that epiphytes, to flourish, need a low rate of evaporation combined with efficient water-holding ability of the bark of trees (Richards, 1932). This combination of conditions occurs in the cool shady ravines and glens in Pennsylvania and it is only in this type of habitat that corticolous mosses are found abundantly.

The response of Bryophytes to edaphic factors is sharper and clearer than in flowering plants (Richards, 1932 and Sharp, 1939). The fact that mosses are close to the substrate and apparently absorb moisture and mineral substances through their delicate rhizoids, may account for this marked response. Many species are narrowly limited to specific substrates. The very physical nature of the soil itself, whether it is clayey or sandy, seems to determine the presence or absence of some species of mosses (Richards, 1932). *Pogonatum pensilvanicum* prefers bare clay soil while many species of *Polytrichum* appear to flourish best in sandy soil. Humus, rotting-wood, bark of trees and various types of rock surfaces are populated frequently by some species of mosses that occur on no other substrate.

Some mosses, known as calcicoles, prefer a substrate containing soluble lime; several of these are listed above. Some other species are definitely calcifuge, while a few like *Ceratodon purpureus* and *Cirriphyllum Boscii* seem to have no preference one way or another. Care must be taken in the analysis of the substrate, as frequently acid humus on top of limestone may lead to the designation of a calcifuge species growing on this humus, as a calcicole.

This brings up the question of hydrogen-ion concentration. As pointed out by Sharp (1939) there is no substrate character that has been more thoroughly investigated than that of pH. In Pennsylvania, as elsewhere, the mosses growing on the humus and debris of the forest floor are distinctly acid, ranging from a pH of 4 to 6. The mosses which prefer this acid substrate are the *Polytrichaceae*, many of the *Hypnaceae* and related families,

the genera *Dicranum* and *Leucobryum*. On the other hand *Funaria hygrometrica*, *Physcomitrium turbinatum*, *Rhodobryum roseum*, species of *Bryum*, *Anomodon* and *Orthotrichum* are circumneutral and examples of a class of mosses growing from pH 6 to 8. As might be anticipated, there are a few species like *Ceratodon* and some *Mniums* which are found growing over a wide range of pH.

Attention should be called to the distribution of mosses on slopes in respect to the pH of the soil. Glenn and Welch (1931) have pointed out that the pH rises from a low of 4 or 5 at the top of a wooded slope to 6 or 7 and even 8 at the bottom, usually along a stream bank. The species of mosses present change from acid-loving, xeric species at the top to circumneutral, mesic and aquatic species at the bottom. This has been found to be generally true in stream valleys in Pennsylvania. However, where hemlock is the dominant tree, the pH at the bottom of the slope may not go above the neutral point (pH 7). Consequently there is a transition from the acid-xeric types of moss communities at the top of the slope to the more circumneutral-mesic communities at the foot.

ASSOCIATES AND SUCCESSION

The influence of living organisms in the environment of the various species of mosses constitutes the biotic factor. In this study attention has been focused primarily on the vegetation. A discussion of the relationships of higher plants to certain moss communities has already been given. From observation it seems that lichens, liverworts and the mosses have a closer and more intimate effect among themselves in matters of invasion and succession than the higher plants have upon them. Certain relations observed again and again are worth recording at this point.

It has been generally observed that in many successions the *Pleurocarpous* species will in time overgrow and crowd out the *Acrocarpous* mosses. The creeping habit of the *Pleurocarps* gives them an advantage over the erect habit of the other group. In the tight cushions and tufts of *Acrocarpous* species, it is rare that one does not find some *Pleurocarpous* species invading.

It has been demonstrated that most moss succession is from alkaline to acid condition (Glenn and Welch, 1931). Field notes made from observation throughout the part of Pennsylvania covered, uphold this statement. The moss plants themselves, by accumulating soil and humus and by building a deep cushion of dead and decaying plants under their new growth, aid considerably in changing the pH of their own environment, frequently making it unsuitable for themselves, but more attractive for invading species. The leaching of calcium or other minerals from rock surfaces sometimes accounts for the change (Glenn and Welch, 1931).

On bare rock surfaces *Grimmia pilifera* seems to be the pioneer in many cases. After this species has accumulated a small amount of soil, *Anomodon attenuatus* invades, eventually crowding out the *Grimmia*. This species accumulates a fine textured, black soil at the base of the thick carpet-like

growth. When these mats of *Anomodon* grow on a moist shaded rock face, *Thuidium delicatulum* invades the mat. *Anomodon rostratus* also gets started in these mats and restricts *A. attenuatus* to the periphery of the mass.

The association of *Aulacomnium heterostichum* and *Bartramia pomiformis* is quite common and has been observed by Steere (1933). *Dicranella heteromalla* seems to like the same habitat condition and has been noticed frequently growing with the above species.

In many collections of *Thuidium delicatulum*, made in swampy hemlock bottoms, it has been found interwoven with the hepatic *Trichocolea tomentella* (Ehrh.) Dumort. The superficial resemblance of the two species is quite striking.

On eroded clay banks or where fresh cuts have been made along roads, trails and stream banks there occurs an interesting succession involving *Pogonatum pensilvanicum* and the lichen *Baeomyces roseus*. This has been brought to the attention of bryologists by Conard (1939) and is treated in detail under the species *P. pensilvanicum*.

Additional treatment of associations and successions is given whenever possible under each individual species.

CONCLUSION

In concluding the discussion on distribution, it is apparent to the writer that microhabitat is the important factor in the distribution of mosses in Pennsylvania. The moss communities found occurring in the various provinces and forest types are the direct results of the factors controlling the microhabitat. These factors of light, temperature, moisture, soil and biological competition are naturally influenced by the macroclimate, topography, forest cover and glaciation, but it is the microhabitat of the site itself which finally determines the moss species that shall grow there.

TAXONOMIC STUDIES

On the following pages are reported all the species of mosses (Bryales) which are known from Central and Eastern Pennsylvania. For each species are included notes relative to its frequency, substrate, habitat, associates, reproduction and a list of the counties from which material has been seen. All specimens seen from east of the line formed by the western boundary of McKean, Elk, Clearfield, Cambria and Somerset Counties and new records for the counties west of that line are cited. The writer has also added published records, east of the above line, for which he has been unable to locate specimens. In the citation of individual specimens, the collectors' names are given with their field collection number or date. A number, unaccompanied by a collector's name, indicates the author's collections. The following abbreviations are utilized in the citations:

A. Academy of Natural Sciences, Philadelphia.
C. Chicago Museum of Natural History.
J. Jennings, Manual of Mosses of Western Pennsylvania.

NY New York Botanical Garden.
PC Porter Catalogue.
SMS Sullivant Moss Herbarium.
TM Manuscript of Miss Grace M. Tees.
No letter following a citation indicates the Herbarium of the University of Pennsylvania.

The arrangement of the classes, orders and families adopted in this list follows that of Schaffner (1938) and Sharp (1939). The number of species of mosses reported in this list is 249 with 32 varieties, but with more intensive collecting in that part of the state not previously worked, this number will be increased.

Keys to classes, orders, families, genera and species are provided and are adapted from various sources. These keys apply only to the species occurring in the area covered by this paper.

BRYALES (*Odontocarpae*)

(Adapted from Sharp, 1939)

A. Sporangium without a columella; spores very large; operculum and peristome none; small acrocarpous mosses . . . . . I. *Archidiales.*

A. Sporangium with a definite columella; spores relatively small; mostly with an operculum and peristome, but some cleistocarpous; acrocarpous and pleurocarpous . . . . . B.

B. Peristome teeth thin, derived from the cell-walls of a single layer of cells, always transversely barred; sometimes entirely wanting . . . . . C.

B. Peristome teeth cellular, rarely absent, if present derived from several layers of cells, not transversely barred, or, if faintly barred, then the capsule decidedly dorsiventral and zygomorphic . . . VII. *Polytrichales.*

C. Peristome single, rarely wanting; usually acrocarpous mosses . . II. *Dicranales.*

C. Peristome double or sometimes wanting; endostome thin and membranous, sometimes lacking . . . . . D.

D. Endostome mostly imperfectly developed or sometimes wanting; thickening of outer surface of exostome teeth greater than that of the inner; mostly pleurocarpous mosses . . . . . III. *Leucodontales.*

D. Peristome distinctly double and the endostome usually well developed, except in Astomous groups; pleurocarpous or acrocarpous . . . . . E.

E. Endostome segments absent or, when present, alternating with the teeth of the exostome; hypophsis lacking or minute; pleurocarpous or acrocarpous . . . F.

E. Endostome processes when present, opposite the teeth of the exostome, either free or united with them, but the peristome sometimes entirely wanting; hypophsis sometimes highly developed; acrocarpous mosses . VI. *Splanchnales.*

F. Cilia usually wanting, gametophyte usually flattened, the leaves inequilateral; alar cells not differentiated; calyptra usually mitriform; mostly pleurocarpous . . . . . IV. *Hookeriales.*

F. Cilia usually present; gametophyte occasionally flattened, leaves variable in shape; calyptra cucullate; alar cells variable; pleurocarpous and acrocarpous . . . . . V. *Hypnobryales.*

ORDER I. ARCHIDIALES

Archidium ohioense Schimp. Very rare.

Published record not seen: Lancaster, along the Tucquan Creek, Porter, PC.

ORDER II. DICRANALES

A. Leaves in more than 2 rows on the stem . . . . . B.
A. Leaves in two rows on the stem . . . . . VIII. *Fissidentaceae.*
B. Gametophytes gray-green, with colorless cells in the thick leaves
II. *Leucobryaceae.*
B. Gametophytes light green to almost black; leaves usually one-cell in thickness; colorless cells infrequent . . . . . C.
C. Calyptra covering the entire capsule . . . . . VII. *Encalyptaceae.*
C. Calyptra not covering the entire capsule . . . . . D.
D. Gametophyte dark, brownish or blackish, growing on rocks; seta short, peristome teeth red or brown . . . . . V. *Grimmiaceae.*
D. Gametophyte usually green, on various substrate; seta long or short, peristome teeth variously colored . . . . . E.
E. Gametophyte and sporophyte 1 cm. or less; found on rocks; leaves smooth, usually awned . . . . . IV. *Seligeriaceae.*
E. Gametophyte and sporophyte usually exceeding 1 cm.; found on various substrate; leaves frequently papillose, sometimes awned . . . . . F.
F. Gametophytes of most species with falcate-secund leaves; peristome teeth usually triangular-lanceolate and bifid half their length . . . I. *Dicranaceae.*
F. Gametophytes of few species with falcate-secund leaves; peristome teeth usually linear, or split to the base, or lacking, or capsules astomous . . . G.
G. Leaves very slender; leaf-cells smooth . . . . . III. *Ditrichaceae.*
G. Leaves broad to slender depending on the species; leaf-cells papillose
VI. *Tortulaceae.*

I. DICRANACEAE

A. Alar cells not conspicuously enlarged . . . . . B.
A. Alar cells conspicuously enlarged . . . . . F.
B. Leaf-cells papillose . . . . . C.
B. Leaf-cells essentially smooth . . . . . D.
C. Peristome teeth undivided and without median line . . . . . 3. *Oreoweisia.*
C. Peristome teeth divided . . . . . 5. *Dichodontium.*
D. Leaf crisped when dry . . . . . E.
D. Leaf not crisped when dry . . . . . 1. *Dicranella.*
E. Gametophytes less than 5 mm. high; capsule erect and not strumose
2. *Rhaodoweisia.*
E. Gametophytes more than 5 mm. high; capsules inclined and strumose
4. *Oncophorus.*
F. Costa with bands of stereid cells . . . . . G.
F. Costa without bands of stereid cells . . . . . 8. *Paraleucobryum.*
G. Costa relatively narrow, capsule with stomata . . . . . 6. *Dicranum.*
G. Costa relatively broad; capsule without stomata . . . . 7. *Dicranodontium.*

1. DICRANELLA Schimp.

A. Seta yellowish, sometimes becoming dark with age . . . . . B.
A. Seta red . . . . . C.
B. Capsule sulcate, mouth incurved when dry . . . . . *heteromalla.*
B. Capsule scarcely plicate, mouth erect when dry . *heteromalla*, var. *orthocarpa.*
C. Leaves entire . . . . . D.
C. Leaves serrate or denticulate . . . . . *varia.*

D. Leaves subsquarrose, from a sheating base . . . . . *Schreberi.*
D. Leaves secund or erect, pellucid by reason of very large thin-walled cells *rufescens.*

(*Dicranella crispa* (Hedw.) Schimp. Excluded because of its western range. Published, not seen: Carbon, Rau, PC; Lancaster, Dillerville Swamp, James, PC; Lehigh, Rau, PC.)

Dicranella heteromalla (Hedw.) Schimp. Common. Widespread throughout the state, but more common in the mountainous areas.

SUBSTRATE: Soil and decaying logs. Ph4 to 5.3.

HABITAT: All forest types of the state. Wooded hillsides, wood roads and stream banks. Elevation from 150 to 2200 feet.

ASSOCIATES: Growing with *Pohlia nutans* and *Tetraphis pellucida.*

REPRODUCTION: Antheridia and archegonia shriveled and brown by July. Capsules mature and closed in September, November and December collections. Open and spores still present in March. (32 specimens examined, 12 fruiting.)

COUNTIES: Berks, Carbon, Clinton, Delaware, Elk, Lehigh, Luzerne, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Potter, Schuylkill, Susquehanna. (16 counties). Published, not seen: Center, Matternville and Bear Meadow, J.

Dicranella heteromalla (Hedw.) Schimp., var. **orthocarpa** (Hedw.) Paris. Commoner than the species and generally distributed in eastern half of the state.

SUBSTRATE: All types of soils, rotting logs and rocks covered with humus. pH range from 4 to 6. More frequently 4 to 5.

HABITAT: All forest types of the state. Mountain tops, wooded hillsides, roadbanks, streambanks, lake shores, old fields and bases of trees. Elevation from 50 to 2567 feet.

ASSOCIATES: With *Atrichum* spp., *Polytrichum* spp., *Leucobryum glaucum*, *Aulacomnium heterostichum*, *Bartramia pomiformis*, *Hypnum* spp., *Ditrichum pallidum* and species of *Cladonia.*

REPRODUCTION: Immature capsules in August. Mature capsules closed until December and January, open and shedding spores from February until March. (142 specimens examined, 119 fruiting.)

COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Carbon, Center, Chester, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Delaware, Elk, Franklin, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Venango, Warren, York. (43 counties.)

Dicranella rufescens (Smith.) Schimp. Rare. On wet soil along streams and at the edge of swamps.

COUNTIES: Cambria, Galitzen, James (A); Lancaster, Dillerville Swamp, Porter (A); McKean, 6 collections of Burnett (NY & A); Philadelphia, Wissahickon, James (A). (4 counties). Published, not seen: Delaware, Painter's Arboretum, Krout, TM; Elk, McMinn, PC; Huntingdon, Porter, PC; Monroe, James, PC.

Dicranella Schreberi (Hedw.) Schimp. Rare. On clayey stream banks and wet cliffs. (3 specimens.)

COUNTIES: Lancaster, Dillerville, James (A); Monroe, Bushkill, Bartram 8/17/21 (NY). (2 counties.)

(*Dicranella subulata* (Hedw.) Schimp. Excluded species. Reported by Porter from Lancaster County, but no specimens are preserved. Mrs. Britton refers those from the above locality to *D. heteromalla* — the form with the curved pedicels. See Porter Catalogue, footnote p. 16.)

Dicranella varia (Hedw.) Schimp. Not common. Scattered over the state. On soil and rock surfaces. (16 specimens.)

COUNTIES: Delaware, Lancaster, Lehigh, McKean, Montgomery, Northampton, Philadelphia. (7 counties). Published, not seen: Chester, James, PC and Chester Valley, Kaiser, SMS.

2. RHABDOWEISIA B.S.G.

A. Leaves serrulate above . . . . . *denticulata.*

A. Leaves narrowly acute and almost entire . . . . *denticulata* var. *americana.*

Rhabdoweisia denticulata (Brid.) Bry. Eur. Rare. Confined to the northern counties.

SUBSTRATE: Sandstone and conglomerate.
HABITAT: Shaded ledges and crevices of rocks.
COUNTIES: Carbon, Onoko Glen, Wolle (NY) and Stony Creek, Wolle (NY); McKean, Hawkins, Burnett 585 (NY) and Toad Hollow, Burnett 2591 (NY); Northampton, Easton, Rau (NY) and Porter, 11/10/68 (A); Pike, East Branch Falls, Rau (NY) and Little Bushkill Creek, Bartram, (NY). Published, not seen: As *R. crispata* (Dicks.) Kindb., Philadelphia, Kaiser, Bryologist **19.**

Rhabdoweisia denticulata (Brid.) Bry. Eur., var. **americana** Culmann. Rare. Published as *R. fugax* in previous publications.

COUNTIES: Carbon, Stony Creek, Rau (NY); McKean, Toad Hollow, Burnett 8/1/97 (NY) and Hawkins, Burnett (A); Northampton, Easton, 9/82 (NY) and Delaware Water Gap, Musci Appl. Austin 71 (A); Pike, Bushkill, Wolle 7/1/74.

3. OREOWEISIA De Not.

Oreoweisia serrulata (Funck.) De Not. Rare. On moist rock faces and in crevices.

COUNTIES: Bucks, Narrowsville, James 11/67 (A & NY); Monroe, Delaware River below Bushkill, Bartram (NY), Indian Rock, Bartram 653 (NY), Buck Hill Falls, Wolle 6/74 (NY), Delaware Water Gap, Musci Appl. Austin 70 (A); Pike, Bushkill, Wolle 7/74 and Wolle 8/73. Published, not seen: Carbon, Rau, PC; Franklin, Mercersburg, Porter, PC.

4. ONCOPHORUS Brid.

A. Leaf base ovate; alar cells usually quite distinct; leaf margins mostly of two layers of cells and recurved . . . . . *virens*

A. Leaf base obovate; alar cells usually not distinct; leaf margin often not recurved . . . . . B.

B. Plants light green, usually on decayed wood; upper lamina of leaf unistratose . . . . . *Wahlenbergii.*

B. Plants fulvous, usually on rocks; upper leaf lamina bistratose . . . *Rauei.*

Oncophorus Rauei (Aust.) Grout. Very rare.

Type locality: Carbon County, Onoko Glen near Mauch Chunk, 700 feet, on shaded dry rocks, A. T. Beals (A).

Oncophorus virens (Hedw.) Brid. Rare.

COUNTIES: Cambria, Wilmore, James 7/61 (A); Monroe, Tobyhanna, Porter 11/68 (A); Pike, Salsbury, Rau 7/18/80 (NY). (3 counties.)

Oncophorus Wahlenbergii Brid. Rare. On rocks, soil and logs in shaded situations.

COUNTIES: McKean, five collections by Burnett (NY). Published, not seen: Lehigh, Rau, TM.

5. DICHODONTIUM Schimp.

Dichodontium pellucidum (Hedw.) Schimp. Rare. Rocky streams in cool moist places.
COUNTIES: Monroe, Wolle, 8/21/73.

6. DICRANUM Hedw.

A. Capsules straight and erect or nearly so, never strumose . . . . . B.
A. Capsules curved and cernuous, strumose in some species . . . . . E.
B. Leaves papillose on the back about ½ the way down, crisped when dry, not secund . . . . . *montanum.*
B. Leaves smooth on the back or slightly rough near the apex, straight, or more or less secund and crisped . . . . . C.
C. Costa excurrent in all leaves . . . . . D.
C. Costa not excurrent; stems usually bearing flagellae in the axils of the upper leaves . . . . . *flagellare.*
D. Margin and costa of leaves entire; apex usually broken . . . . . *viride.*
D. Margin and costa of leaves serrulate . . . . . *fulvum.*
E. Upper leaf cells 1–2:1, rarely more, their walls not pitted . . . . . F.
E. Upper leaf cells more elongated, more or less pitted . . . . . J.
F. Plants robust, leaves undulate or rugose . . . . . G.
F. Plants medium sized to slender; leaves not rugose (except occasionally in *condensatum*) . . . . . I.
G. Leaves erect-open when dry, rarely somewhat crisped, obtuse . . . . . *Bergeri.*
G. Leaves more or less crisped when dry, acute . . . . . H.
H. Leaves ovate to ovate-lanceolate, widest a little below the middle, finely papillose over all the upper dorsal surface; setae solitary . . . . *spurium.*
H. Leaves oblong-lanceolate; broadest at or near the base, more or less roughened with coarse papillae on the upper dorsal surface; setae usually aggregate . . . . . *Drummondii.*
I. Leaves strongly falcate-secund and crisped when dry . . . . . *fuscescens.*
I. Leaves not secund, often straight . . . . . *condensatum.*
J. Leaves undulate; setae aggregate . . . . . *rugosum.*
J. Leaves not undulate (sometimes slightly so in *Bonjeani*) . . . . . K.
K. Leaves with a slender strongly serrate apex, strongly falcate-secund, never undulate . . . . . *scoparium.*
K. Leaves laxly spreading, rarely secund, sometimes slightly undulate, with broad, often obtuse apex . . . . . *Bonjeani.*

Dicranum Bergeri Bland. Rare. Confined chiefly to the "cool" area, reaching its southern limit in the state. In bogs.

COUNTIES: Northampton, Rau (A); Pike, Wolle, 1873. (2 counties). Published, not seen: Bucks, Rau, PC; Chester, "Flora Cestrica," PC; Delaware, Smith, PC.

Dicranum Bonjeani De Not. Fairly common. Chiefly confined to the "cool" area.
SUBSTRATE: Wet soil and humus.
HABITAT: Principally in the eastern hemlock formation. Peat bogs, swamps, stream banks, moist thickets and wet shaded roadsides. Elevation from 500 to 2500 feet.
ASSOCIATES: With *Polytrichum* spp., *Plagiothecium* spp., and twice in the shade of *Lycopodium* spp.
REPRODUCTION: Capsules mature and closed in July collections. (14 specimens examined, 1 fruiting.)
COUNTIES: Bedford, Bradford, Carbon, Center, Chester, Cumberland, Franklin, Lycoming, Potter, Snyder, Somerset, Wayne, York. (13 counties.)

Dicranum condensatum Hedw. Rare. More common on Coastal Plain of New Jersey.

SUBSTRATE: Sandy soil.
Type locality: Lancaster County, but the co-type found in the herbarium seems to be *D. spurium* Hedw. (4 specimens.)
COUNTIES: Dauphin, Peters Mountain, Small 11/1/92 (NY & A); Lebanon, Mountains about cold spring, Small 9/1894 (NY); Northampton, Bushkill Gap, James 10/69 (A). (4 counties.)

Dicranum Drummondii C. Mull. Rare. The "cool" mountainous area of the state.

SUBSTRATE: On moist soil in shaded places. (6 specimens.)
COUNTIES: Bedford, Chaneysville, True 60; Monroe, Pocono Mountains, Porter (NY & A); Naomi Pines, Small 6/7–11/89 (NY); Pike, N. of Bushkill, Bartram 4/30/21 (NY). (3 counties.)

Dicranum flagellare Hedw. Common in Ridge and Valley, Allegheny Mountain and Plateau Provinces.

SUBSTRATE: Rotting wood and humus. pH4.
HABITAT: All forest types of the state. Swamps, thickets, roadsides, wooded slopes and shale bluffs. Elevation from 600 to 2100 feet.
ASSOCIATES: *Polytrichum* spp., *Hypnum* spp., and various lichens, usually *Cladonia.*
REPRODUCTION: Flagellae usually present at all seasons. The majority of the capsules open and shedding spores in September. (55 specimens examined, 17 fruiting.)
COUNTIES: Bedford, Cambria. Clarion, Clearfield, Clinton, Columbia, Cumberland, Elk, Huntingdon, Indiana, Juniata, Luzerne, McKean, Monroe, Northampton, Potter, Snyder, Somerset, Sullivan, Tioga, Warren. (21 counties.) Published, not seen: Blair, Porter, PC; Carbon, Rau, PC; Chester, "Flora Cestrica," PC; Delaware, Smith, PC; Lancaster, Muhlenberg, TM; and Small, PC; Philadelphia, Wissahickon, Kaiser TM; Pike, Eich's Pond, Moldenke 3332.

Dicranum flagellare Hedw., var. **minutissimum** Grout. Differs from the species chiefly by its small size.

COUNTIES: Clearfield, ½ mile northeast of Bigler, 4553; Brooks Rock, no county given, Wynne 7 (NY).

Dicranum fulvum Hook. Common. Chiefly in the mountainous "cool" area.

SUBSTRATE: Rocks. (Sandstone, shale and quartzite.)
HABITAT: All forest types. On rocks and boulders along stream banks, roads, shale bluffs, lake shores, in ravines and on wooded slopes. Elevation from 400 to 2320 feet.
ASSOCIATES: Commonly with some species of *Cladonia.* Also with a wide variety of mosses.
REPRODUCTION: Capsules open as early as August, but the majority shedding spores in September. (42 specimens examined, 5 fruiting.)
COUNTIES: Bedford, Berks, Carbon, Chester, Clinton, Columbia, Cumberland, Delaware, Fulton, Juniata, Lancaster, Lebanon, Luzerne, Lycoming, McKean, Monroe, Northampton, Pike, Potter, Snyder, Somerset, Union, Venango, Warren, Wayne. (25 counties). Published, not seen: Montgomery, Zieglersville, Tees 528 TM; Philadelphia, James, PC and Wissahickon, Kaiser, TM.

Dicranum fuscescens Turn. Fairly common in the "cool" mountainous region.

SUBSTRATE: Soil, litter and soil accumulation on sandstone.
HABITAT: Chiefly in eastern hemlock formation. Bases of trees, shaded road banks, boulders, ravines and thickets. Elevation from 650 to 2200 feet.
ASSOCIATES: *Dicranum scoparium*, *Pohlia nutans*, *Hypnum imponens*, and species of *Cladonia.*
REPRODUCTION: Capsules mature and closed in October. (14 specimens examined, 1 fruiting.)

COUNTIES: Bradford, Columbia, Fayette, Luzerne, Lycoming, Monroe, Perry, Pike, Snyder, Sullivan, Union. (11 counties.) Exsiccati examined: Austin, Musci Appal. Supp. I 472. Mountains of Pennsylvania to New England and northward and westward (NY).
(*Dicranum majus* Smith. Excluded species. Published records, specimens not seen: Blair, Porter, PC. Very doubtful, E. G. Britton.)

Dicranum montanum Hedw. Rare. On logs and roots of trees in the mountains.
COUNTIES: Bucks, Nockamixon, 5694; Elk, Bennet Branch, McMinn 10/65 (A); Monroe, Pocono Summit, Britton 6/7/89 (NY), Naomi Pines, Britton 8/1/93 (NY); Philadelphia, Wissahickon, Tees 662 (A). (4 counties.) Published, not seen: Huntingdon, Porter, PC.

Dicranum rugosum (Hoffm.) Brid. Not common. Confined mostly to the "cool" area.
SUBSTRATE: On moist shaded soil and rocks.
HABITAT: Chiefly in the eastern hemlock formation. Shaded mountain sides, stream banks and wet woods. Serpentine barrens in Lancaster County. Elevation from 350 to 2320 feet.
ASSOCIATES: *Hypnum* spp. (18 specimens.)
COUNTIES: Bedford, Bucks, Fayette, Huntingdon, Juniata, Lancaster, Lehigh, Monroe, Northampton, Snyder, Tioga, Warren, Wayne. (13 counties). Published, not seen: Chester, Chester Valley, James PC; Fulton, Porter, PC.

Dicranum scoparium Hedw. Commonest species of Dicranum. Widespread.
SUBSTRATE: Soil, rotting wood, humus and soil accumulation on rock surfaces. pH4 to 5.
HABITAT: All forest types of the state. Mountain tops, wooded slopes, stream banks, trails, road banks, ravines, bases of trees, shale bluffs and serpentine barrens. Elevation from 100 to 2320 feet.
ASSOCIATES: Chief associates are *Leucobryum glaucum*, *Hypnum* spp., *Polytrichum* spp., *Thuidium delicatulum* and a wide variety of acid woodland mosses. Also associated with species of *Cladonia*.
REPRODUCTION: Young sporophytes 2 to 3.5 cm. long in June. Capsules mature and shedding spores from September to November. Capsules mostly empty by December. (133 specimens examined, 39 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Cambria, Carbon, Center, Chester, Clearfield, Columbia, Crawford, Cumberland, Dauphin, Delaware, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Warren, York. (42 counties). Published, not seen: Clinton, near Loch Haven, J.

Dicranum spurium Hedw. Not common. Confined to bare rocky slopes and wind gaps of the Ridge and Valley Province.
SUBSTRATE: Shaley and rocky soil.
HABITAT: Oak woods. Barren slopes and shale bluffs.
ASSOCIATES: Chiefly with species of *Cladonia*.
COUNTIES: Bedford, Carbon, Dauphin, Franklin, Fulton, Huntingdon, Lehigh, Monroe, Northampton. (9 counties.)

Dicranum viride (Sull. & Lesq.) Lindb. Rare. Counties of the "cool" mountain area.
SUBSTRATE: Rotting wood and humus.
HABITAT: Birch-beech-maple forests. (9 specimens.)

COUNTIES: Bradford, Columbia Cross Roads, 4038; Cambria, Allegheny Mountains, James 11/62 (A); McKean, Burnett, three records (NY); Monroe, Pocono Plateau, Britton 7/24/93 (NY) and Pocono Mountain, James 11/65 (A); Northampton, Bethlehem, Rau (NY); Pike, Rau (NY). (5 counties.)

7. DICRANODONTIUM

Dicranodontium denudatum (Brid.) E. G. Britton. Limited to the northern mountain counties. Mostly on wet rocks. Elevation from 1600 to 2100 feet. Associated with *Plagiothecium* spp. and *Tetraphis pellucida*. (13 specimens.)

COUNTIES: McKean, Guffey, 5674 and eleven records of Burnett (A & NY); Monroe, Pocono, Porter 8/23/59 (A). (2 counties.)

8. PARALEUCOBRYUM (Lindb.) Loeske

Paraleucobryum longifolium (Hedw.) Loeske. Not common. Locally in a few eastern counties.

SUBSTRATE: Rocks and bases of trees. (6 specimens.)
COUNTIES: Berks, Flying Hill, Wilkens 11/12/27 (A); Bucks, Morrisville, James 10/3/49 (A); McKean, Bradford, Burnett (NY); Monroe, Tobyhanna Mills 9/13/92 (NY) and Pocono Mountain, James 10/69 (A); Northampton, Easton, Porter, 11/67 (A). Published, not seen: Carbon, Rau, PC; Chester, "Flora Cestrica," PC.

H. LEUCOBRYACEAE

LEUCOBRYUM Hampe.

A. Gametophyte generally over 2 cm. long; upper tubular part of leaf longer than the flattened basal portion . . . . . *glaucum.*

A. Gametophyte generally less than 2 cm. long; upper tubular part of leaf shorter than the flattened basal portion . . . . . *albidum.*

Leucobryum albidum (Brid.) Lindb. Rare. Coastal Plain species confined to southeastern and southwestern counties. (5 specimens.)

COUNTIES: Carbon, Stony Creek, Rau (NY) this specimen is questionable; Chester, Chester Valley, James (A); Fayette, Ohio Pyle, Browne 639 (C); Lancaster, Eagle Tavern, Porter (A). (4 counties). Published, not seen: Berks, Hiester, PC; Delaware, James, PC; Huntingdon, Porter, PC; Philadelphia, James, PC.

Leucobryum glaucum (Hedw.) Schimp. Abundant. Forms thick cushions. Occurs in all the Physiographic Provinces.

SUBSTRATE: Soil and humus, rocks and well rotted logs and stumps. pH4 to 5.
HABITAT: All types of woodlands within the state, from the summits of the mountains and dry shaley slopes to wet swampy bottoms, less frequently in old fields and weedy meadows. At elevations from 100 to 2100 feet.
ASSOCIATES: Commonly with species of the following mosses: *Polytrichum*, *Dicranum*, *Thuidium* and *Atrichum*. Also with species of *Cladonia*.
REPRODUCTION: Earliest appearance of sporophytes in collected material on August 19th with setae 1 cm. long. Mature capsules appearing from November through December. (153 specimens examined, 13 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Carbon, Center, Chester, Clearfield, Clinton, Columbia, Cumberland, Dauphin, Delaware, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, York. (42 counties.)

III. DITRICHACEAE

A. Capsule cleistocarpous, dehiscing irregularly and without peristome . . . . B.
A. Capsule with operculum and peristome . . . . . C.
B. Capsules ovoid, beaked, immersed . . . . . 1. *Pleuridium.*
B. Capsule pyriform or long-necked, immersed to long-exserted . . 2. *Bruchia.*
C. Capsule with a slender neck as long as the urn or much longer . . 3. *Trematodon.*
C. Capsule without obvious neck . . . . . D.
D. Leaves distinctly 2-ranked, with sheathing bases . . . . . 4. *Distichium.*
D. Leaves not 2-ranked . . . . . E.
E. Capsules strongly sulcate, slightly strumose . . . . . 5. *Ceratodon.*
E. Capsules (except *D. pallidum*) not sulcate . . . . . 6. *Ditrichum.*

1. PLEURIDIUM Brid.

A. Calyptra mitrate; stomata near the middle of the capsule-wall . . . *palustre.*
A. Calyptra cucullate; stomata basal . . . . . *subulatum.*

(*Pleuridium acuminatum* Lindb. Excluded species. Only the following records with no specimens available: Northampton and Lehigh Counties, Rau, PC.)

Pleuridium palustre (Bruch. & Schimp.) Bry. Eur. Rare. Old fields.

COUNTIES: Philadelphia, Moyamensing, James 5/66 (A). Published, not seen: Chester, Chester Valley, James, PC.

Pleuridium subulatum (Hedw.) Lindb. Rare. Fallow fields. (5 specimens.)

COUNTIES: Delaware, Radnor Township, Kaiser 4/7/10; Lehigh, Rau (A); Northampton, Bethlehem, Porter 1864 (A); Philadelphia, Moyamensing, James 5/31/66 (A) and Kingsessing, Swedes Church, James 5/51 (A). Published, not seen: Chester, Darlington, TM.

2. BRUCHIA Schwaegr.

A. Neck of capsule about the length of the spore-producing region . . . *Sullivanti.*
A. Neck of capsule very short, at times almost inconspicuous . . . . . *flexuosa.*

Bruchia flexuosa (Sw.) C. Mull. Rare, probably overlooked. Meadows, soil under the grass. (3 specimens.)

Type locality: Lancaster, Muhlenberg, type specimen (NY).
COUNTIES: Lancaster; Philadelphia, James 5/66 (NY) and Moyamensing, James 5/31/66 (A). (2 counties). Published, not seen: Bucks, James, PC; Chester, James, PC.

Bruchia Sullivanti Aust. Rare. Meadows. Published, not seen: Philadelphia, James, PC.

3. TREMATODON Mx.

A. Neck as long as urn of capsule . . . . . *ambiguus.*
A. Neck twice as long as urn . . . . . *longicollis.*

Trematodon ambiguus (Hedw.) Hornsch. Rare. Probably overlooked. Moist grassy places and exposed clay banks. (3 specimens.)

COUNTIES: Cambria, Allegheny Mountains, Porter and James (A); Luzerne, near Hazelton, Rau 6/73 (NY); Pike, Rau 8/73 (NY & A). (3 counties). Published, not seen: Carbon, Rau, PC.

Trematodon longicollis Mx. Rare. Moist woodlands. With *Funaria hygrometrica* and *Pohlia nutans.* (3 specimens.)

COUNTIES: Cambria, 1852 (NY); Northampton, Centerville, Schaeffer 8/5/47; Philadelphia, near Tacony, James 6/20/50 (A). (3 counties.)

4. DISTICHIUM Bry. Eur.

Distichium capillaceum (Hedw.) Bry. Eur. Very rare. Shaded limestone ledges.
COUNTIES: Monroe, along the Delaware River, Bushkill, Bartram 6/21/21 (NY).

5. CERATODON Brid.

Ceratodon purpureus (Hedw.) Brid. Very common. Widespread.
SUBSTRATE: Soil, rocks (limestone and shale), cinders, sand and wood. pH range 4 to 7, no preference.
HABITAT: Forests, thickets, old fields, dumps, railroad embankments, walls and curbing along city streets. Elevation from 50 to 1900 feet.
ASSOCIATES: With *Polytrichum commune*, *P. piliferum*, *Funaria hygrometrica*, *Dicranella heteromalla*, and species of *Cladonia*.
REPRODUCTION: Sporophytes 1 mm. long in March, growing to 1.5–2 cm. in length by April. Capsules mature and shedding spores May to August. (74 specimens examined, 43 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bucks, Carbon, Chester, Columbia, Delaware, Franklin, Fulton, Lehigh, Luzerne, Lycoming, McKean, Monroe, Montgomery, Northampton, Philadelphia, Potter. Schuylkill, Snyder, Somerset, Sullivan, York. (25 counties). Published, not seen: Cambria, Cresson, J; Center, 2 records, J; Clinton, Loch Haven, J; Lancaster, Muhlenberg, PC; and Small SMS.

6. DITRICHUM Hampe.

A. Seta of sporophyte bright yellow . . . . . *pallidum*.
A. Seta of sporophyte red to brown . . . . . B.
B. Awn of perichaetial leaf as long as the widened base . . . . . *pusillum*.
B. Awn of perichaetial leaf much shorter than the sheathing base . . . *lineare*.

Ditrichum lineare (Sw.) Lindb. Not common. Probably overlooked. Widespread.
SUBSTRATE: Soil pH5 to 6.
HABITAT: All forest types and meadows. Shady banks, ditches, roadsides and alluvial bottoms. Elevation from 150 to 1600 feet.
REPRODUCTION: Young sporophytes appearing in April. Capsules mature and closed in September through to November. (15 specimens examined, 5 fruiting.)
Type locality: Lancaster County.
COUNTIES: Adams, Cumberland, Dauphin, Delaware, Lehigh, McKean, Monroe, Northampton, Philadelphia, Warren. (10 counties.)

Ditrichum pallidum (Hedw.) Hampe. Common. Widespread.
SUBSTRATE: Soil. pH4 to 5.
HABITAT: All forest types and old fields. Wooded slopes, roadsides, fallow slopes, shale bluffs, serpentine barrens, quarries and rocks along streams. Elevation from 100 to 1550 feet.
ASSOCIATES: *Dicranella heteromalla*, *Funaria hygrometrica* and *Atrichum Macmillani*. Also with species of *Cladonia*.
REPRODUCTION: Capsules mature in April and shedding spores then and through May. (51 specimens examined, 26 fruiting.)
COUNTIES: Adams, Bedford, Bradford, Bucks, Chester, Columbia, Delaware, Elk, Lehigh, McKean, Monroe, Montgomery, Northampton, Perry, Philadelphia Schuylkill, Somerset, Sullivan, Warren, York. (20 counties). Published, not seen: Center, Scotia, Tussey's Mountain and Matternville, J; Lancaster, Muhlenberg, TM and Smithville, Small PC.

Ditrichum pusillum (Hedw.) E. G. Britton. Fairly common. Widespread.
SUBSTRATE: On moist bare soils. pH5 to 6.
HABITAT: Open hardwood and hardwood-pine forests and old fields. Moist wooded hillsides, shores of ponds, along roads and on disturbed soils. Elevations from 75 to 1500 feet.
ASSOCIATES: *Dicranella heteromalla*, *Ceratodon purpureus* and *Bryum* spp.
REPRODUCTION: Capsules mature in September. Open and shedding spores in October and November. Empty capsules present until May. (25 specimens examined, 16 fruiting.)
COUNTIES: Bradford, Center, Chester, Columbia, Delaware, Huntingdon, Lancaster, Lehigh, Montour, Northampton, Philadelphia, Schuylkill, York. (13 counties). Published, not seen: Berks, Fernersville, Tees 280, Mt. Neversink, Wilkins 11/18/27 and Gibraltar Hill, Wilkins 9/15/27 TM; Montgomery, Fraser's Bog, Wismer 1/29/33 and Marble Hall, Tees 348 TM.

IV. SELIGERIACEAE

A. Alar cells of leaves not enlarged . . . . . 1. *Seligeria.*
A. Alar cells of leaves enlarged . . . . . 2. *Blindia.*

1. SELIGERIA Bry. Eur.

A. Seta straight or nearly so; capsules broadest at the mouth . . . . . B.
A. Seta recurved when moist; capsules slightly narrowed at the mouth, or at least no wider than in middle . . . . . *recurvata.*
B. Leaves finely serrulate, the awn long, slender, tapering . . . . . *pusilla.*
B. Leaves entire or nearly so, the awn short, thick and abrupt . . . *calcarea.*

Seligeria calcarea (Hedw.) Bry. Eur. Very rare. On wet limestone rocks.
Published, not seen: Huntingdon, Warrior's Ridge, Porter PC.

Seligeria pusilla (Hedw.) Bry. Eur. Very rare. Damp shaded limestone cliffs.
COUNTIES: Monroe, Indian Rocks, Bartram 580 (NY).

Seligeria recurvata (Hedw.) Bry. Eur. Very rare. Moist shaded limestone rocks.
COUNTIES: Northampton, College Hill, Easton, Porter 11/1863 (A) and Spruce Hill, Easton, Porter 5/16/60 (A).

2. BLINDIA Bry. Eur.

Blindia acuta (Hedw.) Bry. Eur. Very rare. Wet sloping rock faces.
COUNTIES: Monroe, Bushkill, Bartram 836 (NY) and Delaware Water Gap, James 10/71 (A).

V. GRIMMIACEAE

A. Leaf-cells not sinuose or sinuose only in the basal portion of the leaf 1. *Grimmia.*
A. Leaf-cells sinuouse throughout most of the leaf . . . . . 2. *Rhacomitrium.*

1. GRIMMIA Hedw.

A. Columella usually attached to the lid and deciduous with it; capsule immersed, symmetrical, larger than the straight seta . . . . . B.
A. Columella free from the lid and persistent . . . . . C.
B. Leaves muticous, not hyaline-hair pointed, more or less repand or dentate at apex . . . . . *alpicola* var. *rivularis.*
B. Leaves with more or less developed hyaline points . . . . . *apocarpa.*
C. Lower leaf cells sinuose, but shorter than in *Rhacomitrium* . . . . . *pilifera.*

C. Lower leaf cells not sinuose . . . . . D.
D. Seta straight or nearly so, and nearly always longer than the capsule *laevigata.*
D. Seta arcuate or flexuose, nearly always longer than the capsule which is often longitudinally sulcate when dry . . . . . *Olneyi.*

Grimmia alpicola Hedw., var. **rivularis** (Brid.) Broth. Rare.

SUBSTRATE: Rocks in or by streams. pH 8.
COUNTIES: Berks, Stonersville 5901, N. of Reading, Wilkens 12/25/27 (A) and E. of Spangsville, Wilkens 10/30/27 (A); Dauphin, Pillow 5536 and Halifax 5491a; Lancaster, Millersville 2597 & 2592. (3 counties). Published, not seen: Cumberland, Small, PC.

Grimmia apocarpa Hedw. Fairly common. Widespread. (Including varieties **ambigua** and **conferta**.)

SUBSTRATE: Rock. (Limestone, shale and syenite.)
HABITAT: Open woods, vacant lots, quarries and exposed rock surfaces. Shale bluffs, shores of rivers, railroad embankments and face of dam. Elevation 50 to 1100 feet.
COUNTIES: Bedford, Berks, Carbon, Center, Chester, Delaware, Lancaster, Monroe, Northampton, Philadelphia. (10 counties). Published, not seen: Bucks, Richlandtown, Tees 566 TM; Cumberland, Small, PC; Lehigh, Rau, PC; McKean, Burnett, PC; Montgomery, Zieglersville, Tees 525 TM.
(*Grimmia Doniana* Smith. Excluded species. Only records not substantiated by specimens: Northampton County, James and Porter, PC.)

Grimmia laevigata (Brid.) Brid. Very rare. Non-calcareous rocks.

COUNTIES: Lancaster, along the Conestoga Creek, Porter 4/62 (A). Published, not seen: Blair, Tyrone, James PC.

Grimmia Olneyi Sull. Rare. Eastern Pennsylvania. Rocks along stream banks.

COUNTIES: Bucks, Tohickon Creek, Gadsby 7/1/11; Northampton, Pen Argyl, Schaeffer 7/10/47, Easton, Wolle 1893 and Porter 11/67 & 8/70 (A); Philadelphia, Wissahickon, James 8/51 (A). Published, not seen: Chester, French Creek, James PC; Lancaster, Small PC.

Grimmia pilifera Beauv. Commonest species in the state. Widespread.

SUBSTRATE: Rock. (Limestone, conglomerate, quartzite and syenite.)
HABITAT: All type of woodland and old fields. Shale bluffs, shores of lakes and serpentine barrens. Elevation 200 to 2000 feet.
REPRODUCTION: Capsules open and spores present in April. (34 specimens examined, 2 fruiting.)
Type locality: Lancaster, Muhlenberg.
COUNTIES: Adams, Bedford, Berks, Bucks, Chester, Delaware, Franklin, Fulton, Lancaster, Monroe, Northampton, Pike, Sullivan, Susquehanna, York. (15 counties.)
(*Grimmia trichophylla* Grev. Excluded species. Published record but no specimens available: Chester, Darlington TM; Lancaster, Dillerville, Porter 6/60 TM.)

2. RHACOMITRIUM Brid.

A. Leaf with broad, obtuse apex . . . . . *aciculare.*
A. Leaf with slender, acute apex . . . . . *heterostichum* var. *sudeticum.*

Rhacomitrium aciculare Brid. Not common. "Cool" mountainous area of the state.

SUBSTRATE: Rocks.
HABITAT: Eastern hemlock formation. Rocks along stream banks. Elevation from 220 feet to 1850 feet. (13 specimens.)
COUNTIES: Carbon, Dauphin, Lehigh, McKean, Mifflin, Montgomery, Sullivan, York. (8 counties). Published, not seen: Cambria, James PC; Lehigh, Rau, TM.

Rhacomitrium heterostichum (Hedw.) Brid., var. **sudeticum** (Funck.) Jones. Rare. Southern part of the state.

HABITAT: Rocks in hemlock woods along stream banks and shores of ponds. (5 specimens.)

COUNTIES: Lehigh, Rau (A); Philadelphia, Wissahickon, James 5/53 (A); York, Long Level 2012. (3 counties). Published, not seen: Chester, Darlington, TM.

VI. TORTULACEAE

A. Leaf usually narrow, often linear-lanceolate, not broadest above the middle; margin if differentiated, never so above the middle . . . . . B.

A. Leaf usually broad, ovate-oblong, spatulate or lingulate, sometimes differentiated . . . . . K.

B. Basal leaf-cells hyaline, extending up the margin in a distinct band 6. *Tortella.*

B. Basal leaf-cells hyaline, not extending up the margin in a distinct band . C.

C. Leaf involute . . . . . D.

C. Leaf not involute . . . . . E.

D. Basal leaf-cells (especially of the upper leaves) 5–10 times as long as wide; upper leaf-cells distinct; sporophyte immersed . . . 1. *Astomum.*

D. Basal leaf-cells (especially of the upper leaves) 2–6 times as long as wide; upper leaf-cells dense and indistinct; sporophyte exserted . 2 *Weisia.*

E. Leaf long, 2–3 mm., often reaching 4 mm., strongly papillose above; margin undulate and open sinuose . . . . . 5. *Trichostomum.*

E. Leaf not generally longer than 2 mm.; margins plane or revolute . . . . F.

F. Leaf-margins plane (*Barbula convoluta* almost so, slightly recurved at base) . . . . . G.

F. Leaf-margins recurved at base or along one side . . . . . H.

G. Leaf not crisped when dry; peristome lacking . . . . . 3. *Gymnostomium.*

G. Leaf crisped when dry, peristome of 32 filiform teeth . . . *Barbula convoluta.*

H. Margin revolute near the middle; stem not more than 2 mm. high; leaf piliferous; sporophyte immersed . . . . . 9. *Phascum.*

H. Margin revolute near the base or along one side; stems more than 2 mm. high; leaf not piliferous; sporophyte exserted . . . . . I.

I. Stem sparsely radiculose, never tinged with reddish-brown, triangular in cross section; upper leaf cells distinct; papillae low and few; peristome lacking 4. *Hyemnostylium.*

I. Stem radiculose, often tinged with reddish-brown, never triangular in cross section; upper leaf cells papillose (not strongly so in *Didymodon*); peristome 16 or 32 teeth . . . . . J.

J. Peristome of 16 teeth, more or less divided or perforate along median line, erect or twisted to right; upper leaves short, obtuse-lingulate 7. *Didymodon.*

J. Peristome of 32 filiform teeth, strongly twisted to left; upper leaves not as above . . . . . 8. *Barbula.*

K. Leaves without evident papillae or propagula; peristome none . . . . . L.

K. Leaves with evident papillae or propagula or both; peristome of filiform teeth M.

L. Plants minute, bulbiform, protonema persistent, capsule cleistocarpous 10. *Acaulon.*

L. Plants larger, not as above . . . . . 11. *Pottia.*

M. Peristome teeth from a narrow basal membrane, usually short and untwisted, never twisted more than 1 turn . . . . . 12. *Desmatodon.*

M. Peristome teeth from a wide basal membrane, usually twisted more than 1 turn . . . . . 13. *Tortula.*

1. ASTOMUM Hampe.

A. Leaf margins strongly involute; setae solitary . . . . . B.
A. Leaf margins mostly plane; setae often clustered . . . . . *ludovicianum.*
B. Seta much shorter than the capsule . . . . . *Muhlenbergianum.*
B. Seta as long as the perichaetial leaves . . . . . *phascoides.*

Astomum ludovicianum Sull. Rare. No specimens seen.

Published records: Chester, "Flora Cestrica," PC; Delaware, Glenolden, Krout 4/28/07 TM; Northampton, Monocacy, Rau PC.

Astomum Muhlenbergianum (Sw.) Grout. Rare. Old pastures.

Type locality: Probably eastern North America.

COUNTIES: Bucks, Narrowsville, James 4/59 (A); Northampton, Monocacy, Rau 3/73 (A) and Easton, Porter 1868 (A); Philadelphia, Moyamensing, James 5/66 (A). Published, not seen: Berks, Kaiser 5/2/12 SMS; Delaware, Smith TM; Lancaster, Muhlenberg TM; Lehigh, Rau TM.

Astomum phascoides (Hook.) Grout. Rare. Old fields. No specimens seen.

Published records: Chester, James PC; Lehigh, Rau, PC; Northampton, Bethlehem, Rau PC.

2. WEISIA Hedw.

Weisia viridula Hedw. Fairly common. Widespread.

SUBSTRATE: Bare soil, slag and rock surfaces.

HABITAT: Hardwood forests, thickets, old fields and meadows. Frequently in sunny situations on road banks, slag piles, in weedy tangles and on rock outcrops.

REPRODUCTION: Capsules mature in February. Open in March and April. (25 specimens, 8 fruiting.)

COUNTIES: Adams, Bedford, Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, McKean, Montgomery, Northampton, Philadelphia, York. (12 counties). Published, not seen: Chester, James, PC.

3. GYMNOSTOMUM Hedw.

Gymnostomum aeruginosum Smith. Rare. Northeastern part of the state. On moist rocks in limestone regions.

COUNTIES: Bucks, Nockamixon, Rau 6/1/74 (A); Northampton, Bingen, Wolle 11/73, Easton, Porter 11/68 (A) and Porter 6/67 (A); Pike, Bushkill, Wolle 8/26/73. (3 counties). Published, not seen: Huntingdon, Spruce Creek, Porter PC; Lehigh, Rau, PC; Philadelphia, Morris Arboretum, Tees 666 TM.

4. HYMENOSTYLIUM Brid.

Hymenostylium recurvirostrum (Hedw.) Dix. Rare. Wet limestone rocks.

COUNTIES: Bucks, Tinicum, Ruth 167 (A); Lehigh, Rockdale, Wolle 7/28/74 and Rau (A). Published, not seen: Carbon, Parryville, Rau, PC.

5. TRICHOSTOMUM Bruch.

Trichostomum cylindricum (Bruch.) C. Mull. Rare. On moist rocks.

COUNTIES: Cambria, Allegheny Mountains, Porter (A); Chester, James 12/50 and Coventryville 12/30/50 (A). Published, not seen: Carbon, Onoko Glen, Rau and Austin PC; Huntingdon, Alexandria, Porter PC; Lehigh, Bear Creek, Wolle PC; McKean, Toad Hollow, Burnett, J; Monroe, Delaware Water Gap, Rau PC; Northampton, Bear Creek, Wolle PC.

6. TORTELLA (C. Mull.) Limpr.

A. Leaf long, linear-lanceolate, with a very acute apex . . . . . *tortuosa.*

A. Leaf oblong-acuminate, obtusely acute, abruptly mucronate by the excurrent costa . . . . . *humilis.*

Tortella humilis (Hedw.) Jennings. Fairly common. Widespread.

SUBSTRATE: Rocks, bases of trees and decaying wood.
HABITAT: Mixed hardwoods, crevices of rocks, stone walls, shaley banks and decaying logs.
ASSOCIATES: *Cladonia.*
REPRODUCTION: Capsules maturing in spring. (18 specimens, 5 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Berks, Bucks, Cambria, Center, Fulton, Lancaster, McKean, Monroe, Montgomery, Northampton, Philadelphia. (11 counties). Published, not seen: Chester, James PC; Delaware, James PC; Huntingdon, Pennsylvania Furnace, J.

Tortella tortuosa (Turn.) Limpr. Rare. On rocks.

COUNTIES: Carbon, Stony Creek, Wolle 8/74; Lancaster, Porter (A); Lehigh, Rau (A); Northampton, Easton, Porter 11/1/68 (A). (4 counties). Published, not seen: Bucks, Nockamixon, James PC; Cambria, Cresson, James PC; Pike, Rau PC; Philadelphia, Kaiser, Bryologist XIX.

7. DIDYMODON Hedw.

Didymodon recurvirostris (Hedw.) Jennings. Very rare. Usually on calcareous rocks.
COUNTIES: Lehigh, Rockdale, Wolle 7/25/74 (A) and Rau (A). Published, not seen: Montgomery, Zieglersville, Tees 544 TM; Philadelphia, Germantown, Tees 739 TM; Delaware, Darby, Krout 9/26/08 TM.

HYOPHILA Brid.

(*Hyophila Tortula* (Schwaegr.) Hampe. Excluded species. Only published records, no specimens: Lehigh, Rau, PC; Monroe, Pocono Plateau, Austin, PC; Northampton, Bethlehem, Rau PC.)

8. BARBULA Hedw.

A. Leaves squarrose-recurved, reddish; stem reddish-brown . . . . . B.

A. Leaves not squarrose-recurved, gametophyte light or dull yellowish-green *fallax.*

B. Perichaetial leaf long, sheathing, convoluted; stem-leaf very slightly recurved along proximal margin, less than 3 mm. long . . . . . *convoluta.*

B. Perichaetial leaf not convoluted, sheathing, or conspicuously different from rest; stem-leaf margins recurved proximally; leaf generally over 3 mm. long . . . . . *unguiculata.*

Barbula convoluta Hedw. Rare. On calcareous soils. In woodlands and the open.

COUNTIES: Northampton, Easton, Porter 5/68 (A); Snyder, Troxelville 5506a. Published, not seen: Berks, Reading, Wilkens TM: Lycoming, McMinn, PC.

Barbula fallax Hedw. Rare. On moist rocks.

COUNTIES: Lehigh, Rau (A); Monroe, Analomink Creek, James 11/65 (A); Montgomery, Collegeville, Wagner 28 (A); Northampton, Easton, Porter 11/69 (A), and Bingen, Rau 4/74 (A). Published, not seen: Bucks, Narrowsville, James PC; Northumberland, James PC.

Barbula unguiculata Hedw. Rare. On calcareous soil frequently disturbed. Also conglomerate and limestone rocks. Old fields.

ASSOCIATES: *Grimmia pilifera.*
COUNTIES: Berks, Stonersville 5857, three collections of Wilkens (A); Lehigh, West Bethlehem, Ruth 34 (A); Northampton, Weygat, Porter 11/1/62 (A); Easton, Porter 10/21/68 (A) and Easton, James (A); Philadelphia, Cresheim Lane, Kaiser 3/26/10 and Lawrence Hill, James (A); York, James 2/65 (A). Published, not seen: Bucks, Upper Blacks Eddy, True 7/15/25 TM; Chester, James PC; Center, Porter PC; Delaware, James PC; Huntingdon, Porter PC; Lancaster, Small PC; McKean, West Branch Swamp, Burnett J; Montgomery, Plymouth Meeting, Tees 751 TM.

9. PHASCUM Hedw.

Phascum cuspidatum Hedw., var. **americanum** Ren. & Card. Rare. Soil in fields.
COUNTIES: Delaware, Glenalden, Krout 5/12/03; Northampton, Bethlehem, Rau 10/75 (A) and Easton, Porter 11/68 (A); Philadelphia, Bustleton, James 4/66 (A). Published, not seen: Bucks, Morrisville, James PC; Chester, "Flora Cestrica" PC; Lehigh, Rau PC.

10. ACAULON C. Mull.

A. Plants subglobose, more or less three-cornered; seta larger than the vaginule; spores mostly under 30 microns, finely and sharply papillose . . . *triquetrum.*
A. Plants ovoid-bulbose; seta shorter; spores over 30 microns, smooth or finely granulated . . . . . *rubrum.*

Acaulon rubrum (Rohl.) Grout. Very rare. On bare soil.
COUNTIES: Chester, Coventryville, James 12/50 (A); York, Porter 5/77 (A). Published, not seen: Lehigh, Rau PC; Northampton, Rau PC.

Acaulon triquetrum (Spruce) C. Mull. Very rare. On soil.
COUNTIES: Philadelphia, Bustleton, James 10/66 (A).

11. POTTIA Furnr.

Pottia truncata (Hedw.) Furnr. Rare. Soil in fields, under grass and shrubs.
COUNTIES: Philadelphia, Moyamensing, James 12/65 (A). Published, not seen: Bucks, Lehnenburg, Ruth TM; Delaware, Lima, Tees 675 TM; McKean, Bradford, J; Montgomery, Ogontz, Kaiser TM; Northampton, Bethlehem and Oakland Park, Ruth TM.

12. DESMATODON Brid.

A. Leaves not bordered, ending in long hair points; capsule erect and symmetric or nearly so . . . . . *plinthobius.*
A. Leaves bordered by a broad band of lighter cells little different or slightly more elongate, leaves acute . . . . . *Porteri.*

Desmatodon plinthobius Sull. & Lesq. Rare. On limestone rocks.
COUNTIES: Lancaster, Porter (A).

Desmatodon Porteri James. Rare. Limestone rocks.
Type locality: Easton, Pennsylvania, James.
COUNTIES: Northampton, Easton, Wolle and Monocacy, James 5/10/74 (A) and Musci Appal. Austin (A).

13. TORTULA Hedw.

A. Growing on trunks of trees; leaves very concave with costa very short-excurrent and bearing propagula . . . . . *papillosa.*
A. Growing on soil and stones . . . . . B.

B. Hair point on leaf rough; basal membrane nearly equaling the teeth in length . . . . . *ruralis.*
B. Hair point smooth or nearly so; basal membrane narrow . . . . *muralis.*

Tortula muralis Hedw. Rare. On moist stones and brick walls.
COUNTIES: Bucks, Narrowsville, Ruth 146 & 144 (A); Northampton, Easton, Wolle, Porter 1889 and Musci Appal. Austin; Philadelphia, Wissahickon, Long 717 (A). Published, not seen: Lancaster, Levan's Mill, Eby PC.

Tortula papillosa Wils. Very rare. Bark of trees.
COUNTIES: Blair, Tyrone, James 11/52 (A); Philadelphia, Bustleton, James (A).

Tortula ruralis (Hedw.) Smith. Rare. On soil and rocks.
COUNTIES: Bucks, Narrowsville, Porter 11/67 (A); Center, State College, Taylor 12/1/22; Northumberland, James 8/67 (A).

VII. ENCALYPTACEAE

ENCALYPTA (Schreb.) Hedw.

Encalypta streptocarpa Hedw. Rare. On calcareous rocks.
COUNTIES: Lancaster, Porter 4/54 (A); Monroe, Analomink, James (A); Northampton, Easton, James, Musci. Appal. Austin (A). Published, not seen: Cambria, Cresson, James PC; Lehigh, Rau, PC.

VIII. FISSIDENTACEAE

FISSIDENS Hedw.

A. Gametophyte slender, aquatic . . . . . *Julianus.*
A. Gametophyte not aquatic . . . . . B.
B. Leaf with at least a partial border of narrow, elongated cells . . . . . C.
B. Leaf without evidence of a border of narrow, elongated cells . . . . . D.
C. Border usually confluent at apex with the percurrent costa; antheridial buds axillary . . . . . *bryoides.*
C. Border at apex narrow or wanting; antheridial buds at base of stem . *minutulus.*
D. Leaf bordered by several rows of paler, short cells . . . . . *adiantoides.*
D. Leaf, if bordered by paler, shorter cells, with only a single row . . . . E.
E. Costa excurrent into a short point . . . . . *taxifolius.*
E. Costa failing to reach the tip of the leaf . . . . . F.
F. Costa almost reaching the leaf apex; cells 17–20 microns in diameter *osmundoides.*
F. Costa usually ending 8–10 cells below the leaf apex; cells 7–10 microns in diameter . . . . . *subbasilaris.*

Fissidens adiantoides Hedw. Fairly common. Widely distributed over the state.
SUBSTRATE: Soil and rock exposures. (Shale and limestone.) Occasionally on bases of trees and exposed roots.
HABITAT: All forest types of the state. On stream banks, on rock walls, at bases of trees and at the bottom of wooded slopes. Elevation 500 to 1400 feet.
REPRODUCTION: Capsules approaching maturity in August and still closed in October. Empty capsules present in April. (20 specimens examined, 5 fruiting.)
COUNTIES: Bedford, Berks, Bucks, Franklin, Huntingdon, Juniata, Lancaster, Lehigh, McKean, Northampton, Schuylkill, Sullivan, Tioga. (13 counties). Published, not seen: Cambria, Cresson, James and Porter, PC.

Fissidens bryoides Hedw. Rare. On soil.

COUNTIES: Lehigh, Rau (A); Northampton, Spruce Hill and College Hill, Easton, Porter (A); Philadelphia, Bustleton, James (A). (3 counties). Published, not seen: Chester, James, PC; Elk, James, PC; Lancaster, Muhlenberg, PC.

Fissidens bryoides Hedw. var. **incurvus** (Starke) Monken. Commoner than the species.

SUBSTRATE: Wet rocks and soil.
HABITAT: Densely shaded stream banks and springs. (9 specimens.)
COUNTIES: Berks, Delaware, McKean, Northampton, Philadelphia. (5 counties). Published, not seen: Lancaster, Muhlenberg, PC; Lehigh, Rau, PC.

(*Fissidens Bushii* Card. & Ther. No specimens seen. Reported in Grout (1936) 1:19 from near Easton in Northampton County, Small.)

(*Fissidens cristatus* Wils. All specimens found so designated prove to be *F. adiantoides* upon microscopic examination.)

Fissidens Julianus (Mont.) Schimp. Rare. Attached to rocks and timber submerged in swift water. (8 specimens examined.)

COUNTIES: Berks, Bucks, Delaware, Lancaster, Lehigh, Northampton, Philadelphia. (7 counties). Published, not seen: Huntingdon, Porter, PC.

Fissidens minutulus Sull. Rare. On wet rock surfaces in cool shaded habitats. (5 specimens examined).

COUNTIES: Blair, Kittanning Gap, Porter (A); Bucks, Riegelsville, True 9/13/25; Carbon, Stony Creek, Wolle 8/74; Northampton, Easton, Porter 11/1868 (A); Philadelphia, near Schuylkill, James 1864 (A). (5 counties). Published, not seen: Chester, Darlington, PC; Lancaster, Muhlenberg, PC; Lehigh, Rau, PC; McKean, Hawkins Hollow, Burnett, J; Monroe, James, PC.

Fissidens osmundioides Hedw. Rare. Soil and bark of trees along shady brooks and in ravines. (7 specimens examined.)

COUNTIES: Carbon, Onoko Glen, Wolle 1873; Huntingdon, Porter 6/22/90 (A); Lancaster, Dillerville, True 9/11/24 and S. of Lancaster, Tees 656 (A); Lehigh, Rau (A); Monroe, Delaware Water Gap, James (A); Northampton, Easton, Porter (A). Published, not seen: Pike, Rau, PC.

Fissidens subbasilaris Hedw. Rare. Bark at the base of trees in hardwood forests.

HABITAT: Elevation 100 to 850 feet. (3 specimens.)
COUNTIES: Delaware, Crum Creek, Krout 4/18/03; Northampton, Easton, Porter (A); Snyder, Troxelville 5504. (3 counties). Published, not seen: Carbon, Onoko Glen, Rau, PC; Lancaster, Muhlenberg, PC; McKean, Quintuple, Burnett, J.

Fissidens taxifolius Hedw. Commonest species of the genus in the state. Widely distributed.

SUBSTRATE: Bare clayey soil. pH5 to 7.
HABITAT: Most frequently in oak-hickory woods, but also found in thickets and old fields. Along stream banks, at the bases of trees and on newly disturbed clay banks. Elevation 150 to 1000 feet.
ASSOCIATES: Growing with *Dicranella heteromalla*, *Pohlia nutans* and species of *Eurhynchium*, *Hypnum* and *Cladonia*.
REPRODUCTION: Calyptra still present on capsules of plants collected in February. (25 specimens examined, 2 fruiting.)
COUNTIES: Bucks, Dauphin, Delaware, Lancaster, Lehigh, McKean, Montgomery, Montour, Northampton, Northumberland, Philadelphia, York. (12 counties). Published, not seen: Chester, James, PC.

(*Fissidens viridulus* (Web. & Mohr.) Wahlenb. No specimens seen. Reported in Grout (1936) 1:12 a sterile form collected on stones in stream at Strath Haven, Delaware County, Krout.)

ORDER III. LEUCODONTALES

A. Cells in the distal portion of the leaf isodiametric . . . . . B.
A. Cells in the distal portion of the leaf longer than wide . . . . . D.
B. Leaf ecostate, perichaetial leaf with cilia . . . . . III. *Hedwigaceae.*
B. Leaf costate, perichaetial leaf without cilia . . . . . C.
C. Peristome always with linear-lanceolate teeth . . . . . I. *Ptychomitriaceae.*
C. Peristome absent, or, if present, with triangular-lanceolate teeth II. *Orthotrichaceae.*
D. Gametophyte slender, often ½ to 4 feet long, aquatic . VIII. *Fontinalaceae.*
D. Gametophyte shorter, less than 6 inches in length, none strictly aquatic . E.
E. Gametophyte dendroid in habit (obscure in *Climacium Kindbergii*) . . . F.
E. Gametophyte not exhibiting a dendroid habit . . . . . G.
F. Branches pointing in one direction like those of a wind-blown tree; on vertical surfaces of moist, shaded rocks . . . . . VI. *Porotrichaceae.*
F. Branches divergent in several directions; not growing on vertical surfaces of rocks . . . . . VII. *Climaciaceae.*
G. Gametophytes flattened until the leaves appear almost as if in two rows V. *Neckeraceae.*
G. Gametophyte not flattened . . . . . IV. *Leucodontaceae.*

I. PTYCHOMITRIACEAE

PTYCHOMITRIUM Fuern.

Ptychomitrium incurvum (Wahlenb.) Sull. Rare. On rock surfaces and old rock walls. Capsules mature, with calyptra present, in January.

Type locality: Lancaster County, Pennsylvania.
COUNTIES: Berks, Oley Furnace, Wilkins 59 (A); Bucks, Nockamixon, Kaiser 5/3/10; Northampton, Bethlehem, Wolle 7/73 and Weygat, Porter 11/27/07 (A); Philadelphia, Falls of the Pennypack, Krout 7/16/08 and Bustleton, James 9/60 and three other records (A). (4 counties). Published, not seen: Delaware, James, PC; Lancaster, Conewago, Small, PC.

II. ORTHOTRICHACEAE

A. Gametophyte prostrate, with numerous erect, short lateral branches 4. *Drummondia.*
A. Gametophyte more or less erect . . . . . B.
B. Gametophytes forming compact cushions on wet rocks . . . 3. *Amphidium.*
B. Gametophytes, if growing on rocks, not forming compact cushions . . . C.
C. Capsules immersed or emergent, calyptra smooth; leaves not crisped when dry . . . . . 1. *Orthotrichum.*
C. Capsules plainly exserted, calyptra hairy; leaves crisped (except in *U. americana*) . . . . . 2. *Ulota.*

1. ORTHOTRICHUM Hedw.

A. Rock-inhabiting species; peristome single, teeth 16, erect or erect-spreading on dry capsules; stomata immersed . . . . . B.
A. Tree-inhabiting species; peristome double, teeth usually united into 8 pairs, recurved or reflexed when dry . . . . . C.

B. Capsules fully exserted, 16-striate . . . . . *anomalum.*
B. Capsules immersed or emergent, 8 striate . . . . . *strangulatum.*

C. Stomata superficial (i.e. with both guard cells on the surface) . . . . . D.
C. Stomata immersed . . . . . G.
D. Leaves obtuse, broad pointed, margins plane . . . . . *obtusifolium.*
D. Leaves acute, margins revolute or involute . . . . . E.

E. Capsules nearly or quite exserted . . . . . *elegans.*
E. Capsules immersed to emergent . . . . . F.
F. Capsules smooth when dry, completely immersed . . . . . *striatum.*
F. Capsules strongly ribbed when dry, neck immersed . . . . . *sordidum.*

G. Capsules strongly contracted below the mouth when dry and so strongly plicate that the red-brown folds are in contact on the outside when dry and empty . . . . . *stellatum.*
G. Capsules very slightly or not at all contracted, much less strongly plicate, pale whitish or yellowish . . . . . H.
H. Leaves entire, blunt at extreme apex . . . . . *ohioense.*
H. Leaves (some at least) dentate with projecting cells, often apiculate . . I.

I. Leaves mostly acute at apex, not rounded; usually some with an apiculus of a single projecting cell; capsule plainly 8-plicate when dry . . . . . *pumilum.*
I. Leaves obtuse, rounded and some sharply denticulate at apex with several projecting cells; capsule smooth or faintly 8-plicate when dry . . . . *pusillium.*

Orthotrichum anomalum Hedw. Rare. On limestone rocks.

COUNTIES: Bucks, Narrowsville, James 11/67 (A); Delaware, Manoa, Krout 7/4/07; Lancaster, Porter 12/9/65 (A); Montgomery, Pottstown, Krout 7/6/10; Northampton, Easton, Porter 5/68 (A); Philadelphia, Wissahickon, James 5/59 (A).

Orthotrichum elegans Hook. & Grev. Very rare. Bark of trees.

COUNTIES: Bucks, Bedminster, Krout 8/30/06.
(*Orthotrichum Hallii* Sull. & Lesq. Excluded species. Range Rocky Mountains. Published records: Lancaster county, Porter 1862 TM.)

Orthotrichum obtusifolium Brid. Rare. On bark of trees, the following collections all on poplars.

COUNTIES: Monroe, Pocono Mountains, Britton 6/24/93 (A); Philadelphia, Pennypack Creek, James 2/64 (A). Published, not seen: Northampton, Bethlehem, Rau, PC.

Orthotrichum ohioense Sull. & Lesq. Rare. On bark of trees. Capsules mature in April.

COUNTIES: Chester, Laurel, Commons 59 (A); Lancaster, New Texas, Carter (A); McKean, Burnett 3021 (A). Published, not seen: Lehigh, Rau PC; Northampton, Bethlehem, Rau PC; Philadelphia, Wissahickon, James 5/59 TM.

Orthotrichum pumilum Dicks. Rare. Bark of deciduous trees. Elevation 100 to 400 feet.

COUNTIES: Delaware, Strath Haven, Krout 9/21/08; Lehigh, Dorney's Park, Krout 6/11/09; Northampton, Easton, Porter 11/1/67 (A); Philadelphia, Chestnut Hill, 6/5/60 (A). Published, not seen: Lancaster, Safe Harbor, Conewago and Tucquan, Small PC.

Orthotrichum pusillum Mitt. Rare. Bark of trees.

Type locality: Pennsylvania.
COUNTIES: Chester, West Grove, Krout 6/4/09; Philadelphia, Lowe 4/26/02, Wolle 7/73, Darby Road, 6/6/60 (A), Kingsessing and Wissahickon, James 5/62 (A). Published, not seen: Bucks, Kintnersville, Ruth, TM.

Orthotrichum sordidum Lesq. & James. Rare. On bark of trees.

No specimen seen. Published records: Lancaster, Conewago, Small PC; Monroe, Mount Pocono, Garber PC.

Orthotrichum stellatum Brid. Rare. On bark of trees.

COUNTIES: Huntingdon, Alexandria, Porter 8/13/59 (A); Lancaster, Safe Harbor, June 6/59 (A); Philadelphia, Wissahickon and Fairmont Park, James 6/61 (A). Published, not seen: Chester, James PC; Delaware, James PC; Lehigh, Rau PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC; Northumberland, James PC.

Orthotrichum strangulatum Schwaegr. Rare. On rocks.

COUNTIES: Bedford, Saxton, 4566; Bucks, Tohickon Creek, Gadsby 7/1/11; Center, State College, Wahl 7/29/47; Delaware, Darby Creek, Spencer 7/4/07; Lancaster, Porter (A). Published, not seen: Cambria, Cresson, James PC; Northampton, Easton, James PC.

Orthotrichum striatum Hedw. Rare. On trees.

COUNTIES: Monroe, Pocono Forks, James 11/68 (A). Published, not seen: Bucks, Narrowsville, James PC.

2. ULOTA Mohr.

A. Leaf not crisped, scarcely contorted . . . . . *americana.*

A. Leaf contorted or crisped . . . . . B.

B. Capsule smooth except for the small, puckered mouth . . . . . *Ludwigii.*

B. Capsule strongly 8-ribbed . . . . . *crispa.*

Ulota americana (Beauv.) Limpr. Fairly common.

SUBSTRATE: Rock surface. (Limestone and quartzite.)
HABITAT: Eastern hemlock and deciduous forests. Elevation 150 to 800 feet.
ASSOCIATES: *Dicranum fulvum.*
(15 specimens examined.)
Type locality: Pennsylvania (Muhlenberg).
COUNTIES: Berks, Bucks, Chester, Juniata, Lancaster, McKean, Monroe, Northampton, Philadelphia. (9 counties). Published, not seen: Cambria, Cresson, James PC; Center, Matternville, J; Delaware, Lindenberg, Krout 7/14/10 TM; Huntingdon, Porter PC; Lebanon, Penryn, Small PC; Lehigh, Rau PC; Pike, Rau PC; Somerset, Ursina J.

Ulota crispa (Hedw.) Brid. Fairly common.

SUBSTRATE: Bark of deciduous trees. (12 specimens examined.)
COUNTIES: Berks, Cambria, Clearfield, Elk, Lancaster, McKean, Northampton, Philadelphia, Sullivan. (9 counties). Published, not seen: Center, Bear Meadows, Porter PC; Chester, "Flora Cestrica" PC; Delaware, Smith, TM; Lebanon, Porter PC; Monroe, Tobyhanna, Garber and Pocono, James PC; Pike, Rau PC.

Ulota Ludwigii Brid. Rare. Bark of trees.

COUNTIES: McKean, Rutherford, Burnett 3/6/93 (A); Monroe, Pocono Forks, Porter 8/1/60 and James 10/69 (A). Published, not seen: Center, Bear Meadows, Porter PC; Chester, "Flora Cestrica" PC; Delaware, Smith PC; Lancaster, Conewago, Small PC.

3. AMPHIDIUM (Nees) Schimp.

A. Autoicous; leaf margins plane; perichaetial leaves entirely smooth, not papillose above . . . . . *lapponicum.*

A. Dioicous; leaf margins more or less recurved; perichactial leaves papillose near the apex . . . . . *Mougeotii.*

Amphidium lapponicum (Hedw.) Schimp. Rare. Wet rocks and crevices of rocks.

COUNTIES: Bucks, Narrowsville, Porter (A); Franklin, Mercersburg, Porter 8/52; Monroe, Buck Hill Falls, Britton 7/14/89 (NY) and Delaware Water Gap (NY); Northampton, Easton, Rau 1872 (NY), Bushkill Gap, Porter 11/10/65 (A) and Bangor, Porter 11/68 (A). (4 counties). Published, not seen: Carbon, Rau PC; Delaware, Smith TM; Huntingdon, Porter PC; Pike, Rau PC; Philadelphia, Wissahickon, James PC.

Amphidium Mougeotii (Bry. Eur.) Schimp. Rare. On damp shaded rock.

COUNTIES: Bucks, Narrowsville, Porter 11/28/67 (A); Monroe, Delaware Water Gap, Garber 11/6/68 (A); Philadelphia, Wissahickon, James 4/59 (A); Pike, Rau (NY). (4 counties).

4. DRUMMONDIA Hook.

Drummondia prorepens (Hedw.) Jennings. Rare. On bark of trees.

COUNTIES: Lancaster, Conewago, Small 1/1/92 (A), New Texas, Carter 12/93 (A) and Safe Harbor, James 6/18/59 (A); Lehigh, Rau (A); McKean, Quintuple, Burnett 456 (A); Northampton, Easton, Porter 1868 (A) and Weygat 11/67 (A). Published, not seen: Chester, James PC; Delaware, James PC; Philadelphia, James PC.

III. HEDWIGIACEAE

HEDWIGIA Hedw.

Hedwigia ciliata Hedw. Common. More frequent in the mountainous areas.

SUBSTRATE: On dry non-calcareous rocks. (Shale, serpentine, trap and conglomerate.)
HABITAT: Woodlands and in old fields. Shale bluffs, serpentine barrens, roadsides and south-facing slopes. Elevation 200 to 1900 feet.
ASSOCIATES: *Bartramia pomiformis* and species of *Hepaticae* and *Cladonia*.
REPRODUCTION: Capsules mature and shedding spores in April and May. (51 specimens, 11 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bucks, Center, Chester, Cumberland, Delaware, Fulton, Huntingdon, Juniata, Lancaster, Lehigh, McKean, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuylkill, Sullivan. (21 counties). Published, not seen: Dauphin, Peters Mountain, Small PC; Pike, Eich's Pond, Moldenke 3340.

IV. LEUCODONTACEAE

A. Secondary stems little branched; calyptra smooth . . . . . *Leucodon.*
A. Secondary stems profusely branched; calyptra hairy . . . . . *Leptodon.*

1. LEUCODON Schwaegr.

A. Seta shorter than the perichaetial leaves . . . . . *brachypus.*
A. Seta longer than the perichaetial leaves . . . . . B.
  B. Stem-leaf slenderly acuminate, strongly plicate . . . . . *sciuroides.*
  B. Stem-leaf abruptly short-acuminate, scarcely plicate . . . . . *julaceus.*

Leucodon brachypus Brid. Rare. On trees.

COUNTIES: Carbon, Wolle; Lancaster, New Texas, Carter 12/93 (A); McKean, Langmade, Burnett 1276; Monroe, Pocono, Porter (A). Published, not seen: Cambria, Porter and James PC; Chester, Coventry, James PC; Pike, Rau PC.

Leucodon julaceus (Hedw.) Sull. Rare. On trees and rotten logs.

Type locality: Probably Pennsylvania.
COUNTIES: Beaver, Delaware, Lancaster, Monroe, Mercer, Montgomery, Philadel-

phia, Wayne. (8 counties). Published, not seen: Cambria, James PC; Chester, "Flora Cestrica" PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC.

Leucodon sciuroides (Hedw.) Schwaegr. Very rare. On rocks and trees.
COUNTIES: Delaware, Landenberg, Krout 7/14/10.

2. LEPTODON Mohr.

Leptodon trichomitrion (Hedw.) Mohr. Rare. On trees and rocks in moist woods.
COUNTIES: Berks, Bernharts 5836; Lancaster, Porter 3/26/62 (A); Monroe, Bushkill Gap, Porter 11/16/68 (A) and Delaware Water Gap, James 11/68 (A). Published, not seen: Chester, "Flora Cestrica" PC; Delaware, Smith PC; McKean, Burnett PC; Northampton, Rau PC; Philadelphia, Fairmount Park and Byberry, James PC; Pike, Rau PC.

V. NECKERACEAE

A. Leaf not cultriform or lobed . . . . . 1. *Neckera.*
A. Leaf cultriform or complicate-bilobed . . . . . 2. *Homalia.*

1. NECKERA Hedw.

Neckera pennata Hedw. Rare. On trunks of trees in cool moist woods.
COUNTIES: Lancaster, Porter (A) and New Texas, Carter 12/93 (A); Lehigh, Rau (A); Monroe, Pocono, Porter 8/23/59 (A); Northampton, Bergens Station, Wolle 8/72. (4 counties). Published, not seen: Cambria, Cresson, Porter PC; Chester, "Flora Cestrica" PC; Delaware, Smith TM; Franklin, Mercersburg, Porter PC; McKean, Burnett PC; Philadelphia, Fairmont Park PC; Pike, Rau PC.

2. HOMALIA (Brid.) Bry. Eur.

Homalia Jamesii Schimp. Very rare. On moist shaded cliffs and ledges.
COUNTIES: Lehigh, Rau (A); Pike, Wolle and Rau 8/73 (A).

VI. POROTRICHACEAE

POROTRICHUM Brid.

Porotrichum alleghaniense (C. Mull) Grout. Not common. Confined to the northern counties.
SUBSTRATE: Rocks and humus.
HABITAT: Eastern hemlock formation. In swamps and on stream banks. (12 specimens.)
COUNTIES: Bucks, Huntingdon, Lehigh, McKean, Monroe, Northampton, Wayne. (7 counties). Published, not seen: Berks, Friedensburg, Wilkens 1/15/28 TM; Cambria, Cresson, James PC; Lancaster, Martic Forge, Porter PC; Philadelphia, Wissahickon, James PC.

VII. CLIMACIACEAE

CLIMACIUM Web. & Mohr.

A. Capsules 3 to 4 times as long as broad; median leaf cells 7 to 10 times as long as broad . . . . . *dendroides.*
A. Capsules 5–6:1; median leaf cells not more than 7:1 . . . . . B.
B. Gametophytes distinctly tree-like in habit; median leaf cells 5–7:1 *americanum.*
B. Gametophytes obscurely tree-like in habit, often nearly prostrate in dense tufts; median leaf cells 2–3:1 . . . . . *Kindbergii.*

Climacium americanum Brid. Commonest species of the genus in Pennsylvania. In all the physiographic provinces.

SUBSTRATE: Soil, rotting-wood, soil and humus accumulated on wet ledges of silicious, crystalline, conglomerate and limestone rock. pH range from 4 to 8. Most samples above 7.

HABITAT: Prefers dense stands of mixed hardwoods, but also found under mixed stands of pine and hemlock with hardwoods. Less frequently occurring in old fields and grassy thickets. Usually at the base of slopes, under moist shaded ledges, along stream banks and in swampy areas. Elevation 150 to 800 feet.

ASSOCIATES: *Hypnum* spp., *Thuidium* spp., *Atrichum* spp., and *Cirriphyllum Boscii.*

REPRODUCTION: Capsules are mature in November. Spores are shed from this time through December and January. Empty capsules remain on some plants until July. (60 specimens examined, 10 fruiting.)

Type locality: Lancaster, Pa.

COUNTIES: Adams, Berks, Blair, Bradford, Bucks, Center, Chester, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Philadelphia, Schuylkill, Union, York. (19 counties). Published, not seen: McKean, Bradford, Burnett, PC.

Climacium dendroides (L.) Web. & Mohr. A northern species extending into Pennsylvania north of the glacial moraine.

SUBSTRATE: Soil.

HABITAT: Under hemlock-birch-maple forest cover. Stream banks, pond shore and edge of bogs. Elevation 1200 to 1448 feet.

ASSOCIATES: With *Mnium* spp., and *Fissidens* spp.

REPRODUCTION: All material examined in sterile condition. (8 specimens examined.)

COUNTIES: Bradford, Herrickville 3978; Monroe, Buck Hill Falls, Browne; Susquehanna, St. Joseph 3906; Tioga, Niles Valley, 4108, 4112, 4088, 4083; Wayne, Lakewood, Dix 9/13/46. (5 counties). Published, not seen: Chester, Darlington, PC; Dauphin, Harrisburg, Small PC. The following specimens cited in Miss Grace Tees's manuscript as *C. dendroides* prove to be *C. americanum*: Bucks, Center Bridge, Tees 102 (A); Delaware, Wayne, Bartram 4/28/08; Philadelphia, Pennypack, Krout 7/16/08.

Climacium Kindbergii (Ren. & Card.) Grout. Fairly common. More frequently found in the southern and southeastern counties.

SUBSTRATE: Soil, rotting wood and accumulated humus on rock surfaces. pH 4 to 7.

HABITAT: Mixed hardwoods and hardwood-hemlock forests. Swampy areas, stream banks, pond shores and moist areas at the bottom of slopes. Elevation 100 to 1500 feet.

ASSOCIATES: *Mnium* spp., and *Thuidium delicatulum.*

REPRODUCTION: Capsules mature in autumn. Empty capsules present in April. (14 specimens examined, 1 fruiting.)

COUNTIES: Adams, Berks, Center, Lebanon, Lehigh, Monroe, Philadelphia, Somerset, Susquehanna, York. (10 counties). Published, not seen: Bucks, Revere, Long 612 TM; Delaware, Llewelyn Mills, Kaiser 1/21/11 SMS; Lancaster, Mt. Hope and Penryn, Small PC; Luzerne, Lily Lake, Small PC; McKean, Bradford, Burnett PC; Montgomery, Zieglersville, Tees 527 TM.

VIII. FONTINALACEAE

A. Leaf ecostate . . . . . 1. *Fontinalis.*

A. Leaf costate . . . . . 2. *Dichelyma.*

1. FONTINALIS (L.) Myrin.

A. Older cauline leaves typically keeled or keeled-conduplicate, younger cauline leaves and branch leaves keeled, keeled-conduplicate, or concave *antipyretica* var. *gigantea*.

A. Neither cauline nor branch leaves keeled-conduplicate . . . . . B.

B. Leaves dimorphic, cauline leaves and branch leaves similar with intergradation in shape and size more or less absent . . . . . C.

B. Leaves more or less uniform, cauline and branch leaves similar with intergradations in shape or size present (except *F. novae-angliae* var. *heterophylla*.) . . . . . D

C. Cauline leaves more or less firm, narrowly lanceolate, 4–5.5 mm. long, about 1 mm. wide, usually about 1–1.5 times the length of the branch leaves *disticha*.

C. Cauline leaves flaccid, narrowly lanceolate to narrowly ovate-lanceolate, 3–8 mm. long, 0.5–2 mm. wide; usually 1.5–3.5 times the length of the branch leaves . . . . . *Sullivanti*

D. Cauline leaves more or less concave or channelled, majority more or less firm . . . . . E.

D. Cauline leaves slightly concave or almost plane, majority more or less flaccid to very flaccid . . . . . *Duriaei*.

E. Leaves narrowly-lanceolate or oblong-lanceolate, 2–4 mm. long, 0.5–1.25 mm. wide, 3–3.5:1; apices usually more or less acute; plants slender, upper perichaetial leaves usually narrow at the apex, acute or apiculate . . . *dalecarlica*.

E. Leaves slightly distant, usually ovate-lanceolate, 2.5–6 mm. long, 1–2.5 mm. wide, 1.75–4:1; apices usually denticulate, some more or less cucullate; upper perichaetial leaves with apices rounded or subapiculate . . . . *novae-angliae*.

Fontinalis antipyretica Hedw., var. **gigantea** Sull. Fairly common, chiefly confined to the northern mountainous counties. Abundant where found.

SUBSTRATE: Rocks in stream bed.
HABITAT: Cold rocky mountain brooks, under hardwood forests and hemlock-alder thickets. Elevations 450 to 2000 feet.
ASSOCIATES: One collection mixed with *Elodea*.
REPRODUCTION: All collections examined were sterile. (12 specimens examined.)
COUNTIES: Cambria, Ebensburg, James (A); Clinton, Rauchtown 4999; Lancaster, Bart township, Porter 1862 (A); Lehigh, Rau (A); McKean, Corydon, 4457; Monroe, Saylorsburg, Porter (A), Tobyhanna, Porter (A) and Kaiser 7/8/10; Northampton, Slate Valley and Martins Creek, Schaeffer; Sullivan, Lippincott (A). (8 counties.) (A specimen in the Academy of Natural Sciences Herbarium collected by Porter at Martic Forge, Lancaster county and labelled *antipyretica* has been determined as *F. novae-angliae* by Dr. W. H. Welch). Published, not seen: Blair, James PC; Delaware, Smith PC; Philadelphia, James PC; Pike, Rau PC.

(*Fontinalis biformis* Sull. Excluded species. Range is central Ohio and Indiana. Not known from the eastern states. (See Cardot in Grout's Vermont Mosses). Published records not authenticated by specimens: Lancaster, Small PC; McKean, Burnett PC; Pike, Rau PC.)

Fontinalis dalecarlica Bry. Eur. Not common. Widely distributed.

SUBSTRATE: Rocks and stones in brooks.
HABITAT: Shaded brooks and springs. Mixed hardwoods, hardwood and pine and hemlock forests. Elevation 500 to 2000 feet.
REPRODUCTION: Mature closed capsules present on collection made on November 11th. (19 specimens examined, 2 fruiting.)
COUNTIES: Berks, Hamburg, Wilkens (A); Bucks, Narrowsville, Porter (A); Center, Bear Meadow, Porter (A); Chester, Chester Valley, James (A); Columbia, 1 mi. w.

of Red Rock, 2839; Delaware, Heidelberg Township, Krout; Franklin, St. Thomas, 2693; Lycoming, Montgomery, 4381; Mifflin, Milroy, 4418, 4386; Monroe, Merwinsburg, Fogg, Delaware Water Gap, James and Porter (A), Tobyhanna, Porter (A), Buck Hill Falls, Browne 8/20/07; Pike, Milford, 5790; Schuylkill, Pine Grove, Krout; Sullivan, Eaglesmere, Githens 244, Ricketts Glen, Githens 236; Union, Keystone Camp, 4840. (14 counties). Published, not seen: Carbon, Rau PC; Lancaster, Martic Forge, Porter and Mt. Hope, Small PC; Lehigh, Rau PC; Philadelphia, James PC.

Fontinalis disticha Hook & Wils. Very rare. A southern species. Represented in Pennsylvania by the following collections: Monroe, East Branch Lake, Porter 8 1 67 (A); Schuylkill, Pine Grove, Stauffer (A). (2 counties) (Number 524 labelled *F. disticha* Aust. Musci Appalachiani, Supp. I determined as *F. Sullivanti* Lindb. by Dr. W. H. Welch. (A).)

Fontinalis Duriaei Schimp. Very rare. Represented in Pennsylvania by the following collections: Huntingdon, Porter (A) and Spruce Creek, James (A); Northampton, Bethlehem, Schweinitz (A). (2 counties.)

(*Fontinalis Lescurii* Sull. Excluded species. No authentic Pennsylvania specimens available of this species. A specimen labelled *F. Lescurii* collected at Tunkhannock, Monroe County by Porter on June 15, 1859 (A) has been determined as *F. Novae-angliae* by Dr. W. H. Welch. Another specimen collected in a shallow brook, Blue Mountains, North of Hamburg by Wilkens 5, 13 28 (A) has been determined as *F. dalecarlica* Bry. Eur. by Dr. Welch. Published, not seen: Huntingdon, Porter PC; McKean, Burnett PC; Monroe, Mt. Pocono and Water Gap, James PC; Pike, Rau PC.)

Fontinalis Novae-angliae Sull Most common species in Pennsylvania. Widely distributed over the state.

SUBSTRATE: Rocks and dead branches in streams and edge of lakes. pH 7.
HABITAT: Shallow water at edge of lakes and ponds, brooks and spring outlets. Under the shade of hemlock, hemlock-hardwood, and hardwood forests and thickets along streams in old fields. Elevation 75 to 2200 feet.
ASSOCIATES: One specimen heavily incrusted with growth of diatoms.
REPRODUCTION: All specimens examined were sterile. (17 specimens.)
COUNTIES: Adams, Arendtsville, 5791, 5799; Chester, Daylesford, 5798; Delaware, Collingsdale, Krout 7/27/07; Fayette, Markleysburg, 4784; Franklin, St. Thomas, 2692a; Lancaster, Martic Forge, Porter (A); Luzerne, Red Rock, 2881; Monroe, Tunkhannock, Porter (A); Philadelphia, Germantown, Porter (A); Somerset, Roxbury, 5192; Sullivan, Eaglesmere, Githens 242; Susquehanna, Gelatt, 3856; Warren, Russell 2692 and Youngsville 5792; Wayne, Waymart, 3834; York, Hallam, 5794. (15 counties). Published, not seen: Huntingdon, Spruce Creek, Porter PC; Northampton, Rau PC; Pike, Rau PC.

Fontinalis Novae-angliae Sull., var. **cymbifolia** (Aust.) Welch. One collection made in James Brook on top of Broad Mountain, 2 miles north of Nesquehoning, Carbon county, 2798. Elevation 1685 feet.

Fontinalis Novae-angliae Sull., var. **heterophylla** Card. Bradford, Burnett 5/13 96.

Fontinalis Novae-angliae Sull., var. **latifolia** Card. Monroe county, Pocono Forks, Porter 8/9/68 (A).

Fontinalis Sullivanti Lindb. A southern coastal plain species.

COUNTIES: Chester, Falls of French Creek, Krout 5/17/10; Sullivan, C. D. Lippincott (A). (2 counties). (Number 524 labelled *F. disticha* Austin in Musci Appalachiani, Supp. I. Rocky rivulets, mountains of N. J. and Pa. has been determined as *F. Sullivanti* by Dr. W. H. Welch. (A).)

2. DICHELYMA Myrin.

A. Costa long-excurrent . . . . . *capillaceum.*
A. Costa subpercurrent to shortly excurrent . . . . . *pallescens.*

Dichelyma capillaceum Bry. Eur. Rare. On dead wood and humus in swamps and rivulets. Hemlock ravines. (5 specimens.)

COUNTIES: Chester, Chester Valley, James 6/50 (A); Crawford, Rendalls Corners 5773; Lehigh, Rau (A); Monroe, Delaware Water Gap, Rau 11/1/74 (A). (4 counties). Published, not seen: Delaware, Smith TM.

Dichelyma pallescens Bry. Eur. Very rare.

COUNTIES: Monroe, Tobyhanna, James 10/69 (A). Published, not seen: McKean, Bradford, Burnett PC.

ORDER V. HYPNOBRYALES

A. Sporophyte lateral on primary stem or branch . . . . . B.
A. Sporophyte terminal on main axis . . . . . J.
B. Leaf papillose, but without projecting cell ends . . . . . C.
B. Leaf smooth or papillose because of projecting cell ends, except in *Schwetschkeopsis* . . . . . D.
C. Gametophyte usually julaceous, light to glaucous green . . . . I. *Theliaceae.*
C. Gametophyte seldom julaceous, bright green to very dark . . . II. *Leskeaceae.*
D. Capsule erect and symmetrical (*Hypnum imponens* may be sought here.) E.
D. Capsule seldom erect, usually curved . . . . . F.
E. Leaf costate, or if ecostate, then papillose . . . . . III. *Fabroniaceae.*
E. Leaf ecostate and smooth . . . . . IV. *Entodontaceae.*
F. Leaf ecostate or nearly so . . . . . G.
F. Leaf costate, often doubly so except in *Campylium hispidulum* . . . . H.
G. Gametophyte complanate-foliate except in *Plagiothecium striatellum*; leaves seldom secund . . . . . VII. *Plagiotheciaceae.*
G. Gametophyte not complanate-foliate; leaves usually secund . VIII. *Hypnaceae.*
H. Capsules usually ovoid, short, thick and asymmetrical, little contracted below the mouth when dry . . . . . I.
H. Capsules usually longer, arcuate-cylindrical, somewhat contracted below the mouth when dry . . . . . V. *Amblystegiaceae.*
I. Costa single and usually reaching beyond the middle of the leaf; paraphyllia none . . . . . VI. *Brachytheciaceae.*
I. Costa double and usually not long; paraphyllia often abundant and large IX. *Hylocomiaceae.*
J. Leaf smooth . . . . . K.
J. Leaf papillose . . . . . L.
K. Leaf-cells longer than wide . . . . . X. *Bryaceae.*
K. Leaf-cells nearly isodiametric . . . . . XI. *Mniaceae.*
L. Endostome membrane divided above into 64 filiform, appendiculate cilia, forming a kind of delicate net-work . . . . . XIV. *Timmiaceae.*
L. Endostome not as above . . . . . M.
M. Capsule much longer than wide . . . . . XII. *Aulacomniaceae.*
M. Capsule subspherical, very short . . . . . XIII. *Bartramiaceae.*

I. THELIACEAE

A. Paraphyllia present . . . . . 1. *Thelia.*
A. Paraphyllia absent . . . . . 2. *Myurella.*

1. THELIA Sull.

A. Papillae on dorsal surface of leaf not branched . . . . . *hirtella.*
A. Papillae on dorsal surface of leaf branched . . . . . B.
B. Gametophyte growing on trees; leaf margin ciliate . . . . . *asprella*
B. Gametophyte growing on sand or rocks; leaf margin seldom ciliate *Lescurii.*

Thelia asprella Sull. Not common. Chiefly in the mountainous counties.

SUBSTRATE: Bark of trees.
HABITAT: Eastern hemlock formation. On bark of oak and cedar in cool moist ravines and stream valleys. Elevation from 700 to 1500 feet. (12 specimens examined, 5 fruiting.)
ASSOCIATES: With lichens occasionally.
COUNTIES: Bucks, Carbon, Columbia, Lehigh, Monroe, Montgomery, Northampton, Pike, Schuylkill. (9 counties). Published, not seen: Chester, Chester Valley, James PC; Delaware, James PC; Lancaster, Conewago and Mount Hope, Small PC; McKean, Bradford, Burnett PC; Monroe, Tobyhanna Mills, James PC; York, Small PC.

Thelia hirtella (Hedw.) Sull. Rare. On bark of trees.

Type locality: Lancaster, Pa.
COUNTIES: Bucks, Plumsteadville, Garber and Solesbury, Fisher 12/96 (A); Lancaster, Conestoga, Porter 9/7/53 (A); Northampton, Easton, James 11/68 (A). (4 counties). Published, not seen: Delaware, Radnor, James PC; McKean, Gates Hollow, Burnett J; Philadelphia, Fairmount Park, James PC.

Thelia Lescurii Sull Rare.

SUBSTRATE: Soil and rocks.
HABITAT: Oak-hickory woods and stone walls around old fields. Elevation 550 to 700 feet.
REPRODUCTION: Capsules open and spores present in January.
COUNTIES: Berks, Wernersville, Williams 1/6/04 and Oley Furnace, Wilkens 60; Fulton, Warfordsburg 4750.

2. MYURELLA Bry. Eur.

Myurella Careyana Sull. Rare. On rock surfaces of cliffs.

COUNTIES: Lancaster, Porter 8/59 (A) and Cedar Hill, Porter 4/26/62 (A); Montgomery, Ringing Rocks Park, Krout 7/6/10; Northampton, Easton, Rau (A) and Bushkill Gap, Porter (A). Published, not seen: Bucks, Narrowsville, Porter PC; Carbon, Rau PC; Franklin, Mercersburg, Porter PC; Huntingdon, Alexandria, Porter PC; Lehigh, Rau PC; Monroe, Analomink Creek, James PC; Pike, Rau PC.

II. LESKEACEAE

A. Robust plants (except *Anomodon tristis* and *A. rostratus*), without paraphyllia, leaves densely papillose and subopaque; capsules erect and symmetric; peristome with segments narrow and cilia rudimentary or wanting; archegonia on the branches . . . . . 5. *Anomodon.*
A. Plants small to robust; paraphyllia mostly present; capsules and peristome various; archegonia mostly on the stems . . . . . B.
B. Plants with abundant filiform paraphyllia, which are usually branched; capsules curved, peristomes perfect . . . . . C.
B. Paraphyllia less abundant; capsules various; peristomes with cilia rudimentary or often lacking . . . . . D.
C. Paraphyllia felted along the stem and attached to the leaf base . . 2. *Helodium.*
C. Paraphyllia abundant, not felted and not attached to the leaf base . 1. *Thuidium.*

D. Leaves ovate-lanceolate, acuminate, spreading to squarrose when moist, with plane margins; peristome teeth blunt; inner peristome of a scarcely perceptible basal membrane . . . . . 4. *Lindbergia.*
D. Leaves ovate to acuminate, erect-spreading when moist; peristome teeth slender-pointed, segments linear in most species . . . . . 3. *Leskea.*

1. THUIDIUM B.S.G.

A. Apical cell of branch leaves crowned with 2–4 papillae . . . . . B.
A. Apical cell of branch leaves with a single terminal papilla . . . . . G.
B. Paraphyllia numerous, more or less branched . . . . . C.
B. Paraphyllia few, small, mostly linear-oblong, 2–6 cells long . . . . . F.
C. Stems closely once pinnate, branches subjulaceous when dry . . . . . D.
C. Stems loosely pinnate, branches pinnate to bipinnate . . . . . E.
D. Plants comparatively soft; leaf cells with 2–5 small papillae on each surface . . . . . *scitum.*
D. Plants rigid; leaf cells with a single papilla on each surface . . . *abietinum.*
E. Stem leaves spreading-recurved, margins plane, costa percurrent; perichaetial leaves not ciliate; apparently calcicolous . . . . . *recognitum.*
E. Stem leaves erect-spreading, margins recurved, costa vanishing below the apex; perichaetial leaves ciliate; plants very regularly bi-tripinnate. . *delicatulum.*
F. Plants very small, 1–2 cm. stems and branches filiform, branches papillose *pygmaeum.*
F. Plants small, 2–4 cm.; branches smooth . . . . . *minutulum.*
G. Stem leaves roundish-ovate, abruptly acuminate to a broad oblong point; margins erose-serrate . . . . . *virginianum.*
G. Stem leaves rather gradually long-acuminate; margins crenulate-serrate or entire . . . . . *microphyllum.*

Thuidium abietinum (Brid.) Bry. Eur. Rare.

SUBSTRATE: On soil and conglomerate rock.
HABITAT: In ravines and old fields.
ASSOCIATES: Growing with *Hypnum* spp. and *Polytrichum commune.*
(6 specimens examined.)
COUNTIES: Berks, Krumsville, Schaeffer 11/28/47 and Stonersville 5885; Northampton, Weygat, Potter & James (A): (12 counties.)

Thuidium delicatulum (Hedw.) Mitt. Abundant. In all physiographic provinces.

SUBSTRATE: Soil, rotting wood, accumulated humus on rock surfaces. pH 4 to 5.
HABITAT: All forest types, preferring the dense stands. Very common along wooded streams, in dark moist ravines, hemlock bottoms and shaded road banks. An indicator of mesophytic conditions. At elevations between 150 and 2200 feet.
ASSOCIATES: Growing with *Hypnum* spp., *Polytrichum* spp., *Atrichum* spp., and *Cladonia* spp., in the mesophytic forests. Along stream banks and in hemlock bottoms with *Mnium* spp., and the hepatic *Tricocholea tomentella.*
REPRODUCTION: Young sporophytes averaging 2 mm. long were found in a specimen collected in September. Immature capsules were found in August and closed mature capsules in September. Open capsules shedding spores were collected in November. (172 specimens examined, 20 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Carbon, Center, Chester, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin Delaware, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, York. (45 counties.)

Thuidium microphyllum (Hedw.) Best. Rare. More common further south.

SUBSTRATE: Soil, rotting wood and humus on rock surfaces.
REPRODUCTION: Young sporophytes 15 mm. long present on specimens collected May 16. Capsules open on material collected June 17. (4 specimens examined, 2 fruiting.)
COUNTIES: Delaware, Moylan, Spencer 5/30/06; Northampton, Slateford, Schaeffer 7/1/47; Philadelphia, Wissahickon, Krout 1906 (A) and Highlands, Haydock (A). (3 counties). Published, not seen: Berks, Leesport, Wilkens 10/22/27 TM; McKean, Bradford, Burnett J.

Thuidium minutulum (Hedw.) Bry. Eur. Rare. More common southward. On rotting logs and exposed roots. Capsules mature in November. (4 specimens, all fruiting.)

Type locality: Lancaster county, Muhlenberg.
COUNTIES: Blair, Burgoon Gap, Garber 8/1869 (A); Cambria, Allegheny Mountains, James 10/1861 (A); McKean, Bolivar Run, Burnett 2034 (A); Northampton, Easton, Porter 11/13/68 (A). (4 counties). Published, not seen: Carbon, Mauch Chunk, James PC; Chester, Chester Valley, James PC; Delaware, James PC; Huntingdon, Porter PC; Lancaster, Muhlenberg TM; Monroe, James PC and Levis Falls, Moldenke 3343; Philadelphia, Wissahickon PC. Following specimens cited as this species in Tees Mss. from Berks county, have been determined as *T. virginianum*: Blind Hartmans, Wilkens, Nov. 13, 1927 (A) and White Bear, Wilkens, Oct. 20, 1929 (A).

Thuidium pygmaeum Bry. Eur. Rare. Calcareous rocks. Capsules open in September and October. (3 specimens.)

COUNTIES: Northampton, Easton, Porter and James (A). Published, not seen: Lehigh, Rau PC; Philadelphia, James PC.

Thuidium recognitum (Hedw.) Lindb. Not common. Occurs in all physiographic provinces.

SUBSTRATE: Soil and rock surface in limestone regions.
HABITAT: Moist shaded woods. One collection on rock exposure in a limestone sink overgrown by *Juniperus virginiana*. Elevation 550 to 2000 feet.
REPRODUCTION: Immature capsules present in June, empty capsules in December. (8 specimens, 2 fruiting.)
COUNTIES: Bedford, Beans Cove Church 4733; Berks, Bernharts 5882; Franklin, Greencastle 5877 and Housum 4681; Lancaster, Rawlinsville, Carter 6/30/93 (A); McKean, Hazelhurst 5889; Northampton, Slateford, Schaeffer 8/19/47 and Easton, Porter 11/1868 (A): (6 counties). Published, not seen: Clinton, between Renovo and Haneyville, J; Monroe, Pocono, James, PC; Philadelphia, James, PC.

Thuidium scitum (Beauv.) Aust. Rare.

SUBSTRATE: Soil, fallen logs and bases of trees.
HABITAT: Hardwood forest.
ASSOCIATES: One collection mixed with *Thuidium delicatulum*.
REPRODUCTION: Capsules mature and open in late October. (8 specimens, 3 fruiting.)
COUNTIES: Blair, var. *aestivale*, Bald Eagle, James 1/30/59 (A); Lehigh, New Smithville, Schaeffer 11/28/47; McKean, Bradford, Burnett 7/5/96 and Gilbert Run, Burnett 2811, also var. *aestivale*, Burnett Brook, Burnett 2790; Northampton, var. *aestivale*, Bethlehem, Rau (A); Philadelphia, Wissahickon, James 5/65 (A); Pike, Elbow Swamp, Wolle 1873. (6 counties). Published, not seen: Chester, New Garden, James PC; Lancaster, Muhlenberg, TM. Specimen labelled *T. scitum* from Berks county, Gibraltar Hill, Wilkens 10/30/27 cited in the Tees Mss. determined as *T. virginianum*.

Thuidium virginianum (Brid.) Lindb. Fairly common. All provinces of the state in more open and drier woodlands.

SUBSTRATE: Soil and humus covered rocks. (Shale, sandstone and trap.) pH 4.
HABITAT: Under stands of pine, pine-oak and hemlock-hardwoods. South facing wooded slopes, roadsides, shale bluffs and sandstone ledges. Elevation 150 to 1000 feet.
ASSOCIATES: *Atrichum Macmillanii*, *Grimmia pilifera*, *Bartramia pomiformis*, *Hypnum* spp. and lichens of the genus *Cladonia*.
REPRODUCTION: Sporophytes 1 to 1.5 cm. long in April, capsules immature on material collected in May. Capsules open and empty in September and October. (14 specimens examined, 8 fruiting.)
COUNTIES: Adams, Berks, Bucks, Center, Dauphin, Huntingdon, Northampton, Philadelphia, Snyder, Sullivan. (10 counties). Published, not seen: Blair, Bald Eagle Valley, Porter PC; Cambria, Cresson, James PC; Delaware, Krout, 5/30/07 TM; Lancaster, Muhlenberg and New Texas, Small PC; Monroe, Buckhill Falls, PC.

2. HELODIUM (Sull.) Warnst.

Helodium paludosum (Sull.) Aust. Not rare. Widespread. Local.

SUBSTRATE: Soil and humus. pH 4 to 6.
HABITAT: Grassy ditches, marshy spots and wet areas, usually near the edge of hardwood forests. Elevation 100 to 500 feet.
ASSOCIATES: With *Aulacomnium palustre*.
REPRODUCTION: Capsules mature and closed in April. Open in May and June. (9 specimens examined, all fruiting.)
COUNTIES: Bucks, Chester, Delaware, Franklin, Lehigh, Montgomery, Northampton, Philadelphia. (8 counties). Published, not seen: Lancaster, Muhlenberg, TM and Dillerville Swamp, Porter PC; McKean, Bradford, Burnett, J (var. *helodioides* (Ren. & Card.) Grout.)

3. LESKEA Hedw.

A. Leaves papillose, costate; median cells usually isodiametric; peristomial teeth abruptly incurved from a bulging base when dry . . . . . B.
A. Leaves smooth or nearly so, costate or ecostate; peristomial teeth erect when dry . . . . . *nervosa*
B. Leaves ovate-lanceolate, acute to acuminate, more than twice as long as wide . . . . . C.
B. Leaves ovate, subacute to obtuse, less than twice as long as wide . . . D.
C. Capsule straight, operculum short-conic . . . . . *polycarpa*.
C. Capsule curved; operculum long-conic . . . . . *arenicola*.
D. Leaves symmetric, biplicate, margins often revolute . . . . . *gracilescens*.
D. Leaves asymmetric, not plicate, margins plane . . . . . *obscura*.

Leskea arenicola Best. Very rare. Bases of trees.

COUNTIES: Delaware, Chelsea, Krout 5/27/11 TM.

Leskea gracilescens Hedw. Common.

SUBSTRATE: Roots, rotting logs and bark of trees.
HABITAT: Alluvial woods, open hardwoods and juniper trees in old pasture.
ASSOCIATES: With *Mnium cuspidatum* and *Anomodon attenuatus*.
REPRODUCTION: Capsules mature and closed in May. Open and shedding spores in June and July. Empty capsules present until September. (20 specimens, 13 fruiting.) Type locality: Pennsylvania.
COUNTIES: Bucks, Franklin, Fulton, Lancaster, Lehigh, Montour, Northampton. (7 counties). Published, not seen: Berks, Wernersville, Tees 269 TM; Montgomery, Elkins Park, Tees 296 and Arcola, Tees 519a TM; Philadelphia, Pennypack, Tees 299 TM.

Leskea nervosa (Schwaegr.) Myrin. Rare. On bark of trees.
COUNTIES: Delaware, Strath Haven, Krout 9/21/07; Lehigh, Fogelsville, Schaeffer 11/28/47; McKean, Bennett Brook Burnett 7/12/96.

Leskea obscura Hedw. Not common.
SUBSTRATE: On bases of trees and rotten wood and soil.
HABITAT: Hardwoods. Stream banks, ravines and soil deposited on a bridge. Elevation 100 to 640 feet.
REPRODUCTION: Capsules closed in June. Open in July, remaining on the plants until October. (11 specimens, 5 fruiting.)
Type locality: Pennsylvania.
COUNTIES: Bucks, Chester, Delaware, Lancaster, Lehigh, Montour, Northampton. (7 counties). Published, not seen: Blair, Tyrone, James PC; McKean, Burnett PC; Philadelphia, Wissahickon, James PC and Pennypack, Krout 5/30/07 TM.

Leskea polycarpa Hedw. Fairly common. Eastern half of the state.
SUBSTRATE: Bark of trees, rotten wood and rarely on stones.
HABITAT: Woodlands. On exposed roots, old stumps, bases of trees, prostrate trunks and stone walls.
REPRODUCTION: Sporophytes 1 cm. long in April. Mature and closed in June. Open and shedding spores in July. (14 specimens, 5 fruiting.)
COUNTIES: Berks, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia. (7 counties). Published, not seen: Bucks, Ottsville, Long 603 & 604 TM; Chester, Valley Forge, Tees 367 TM.

4. LINDBERGIA Kindb.

Lindbergia brachyptera (Mitt.) Kindb., var. *Austinii* (Sull.) Grout. Very rare. On bark of trees and stones. Frequently on the bark of *Juniperus virginiana.*
COUNTIES: Lehigh, Rau (A); Northampton, Bethlehem, Rau (A). Published, not seen: Lancaster, Dillerville Swamp, Small PC; Monroe, Water Gap, Austin PC.

5. ANOMODON Hook. & Tayl.

A. Secondary stems and branches slender, julaceous when dry . . . . . B.
A. Secondary stems and branches coarse, scarcely julaceous . . . . . C.
B. Leaf acute, ending in a hair point . . . . . *rostratus.*
B. Leaf lingulate, obtuse . . . . . *tristis.*
C. Secondary stems much branched, many branches attenuate to flagelliform; many of leaves apiculate and toothed at the apex . . . . . *attenuatus.*
C. Secondary stems sparingly branched, no attenuate branches . . . . . D.
D. Upper portion of leaves lingulate-lanceolate, tapering to the apex, often secund; usually growing on rock . . . . . *viticulosus.*
D. Upper portion of leaves lingulate and of nearly equal breadth, not secund; plants nearly always growing on bark of trees, stumps or logs . . . . E.
E. Leaves not decurrent having large fimbriate-papillose auricles, often apiculate *Rugelii.*
E. Leaves somewhat irregularly appressed, decurrent, without auricles, not apiculate . . . . . *minor.*

Anomodon attenuatus (Hedw.) Huben. Common. Generally distributed over the state. Forms a thick carpet-like growth.
SUBSTRATE: Exposed rock surfaces, less frequently on bases of trees. Very frequent and vigorous on limestone and conglomerate, but also occurs on shale, sandstone and quartzite. pH 7 to 8.
HABITAT: Deciduous woods, occasionally under hemlock and juniper. Cliffs, ravines,

shale bluffs, talus slopes, serpentine barrens, stream banks and at the bases of trees up to one foot above the soil surface. Elevation 150 to 2567 feet.
ASSOCIATES: Overgrows *Grimmia pilifera* and is itself overgrown by *Anomodon rostratus*, *Thuidium delicatulum* and species of *Cladonia*. This and other species of *Anomodon* accumulate a very fine dark soil at the base of the carpet-like masses preparing the way for more mesic species of mosses.
REPRODUCTION: Capsules open and empty on material collected in December and January. (42 specimens examined, 3 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bucks, Center, Chester, Dauphin, Delaware, Franklin, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, Somerset, Sullivan, York. (17 counties). Published, not seen: Huntingdon, Pennsylvania Furnace J; McKean, Bolivar Run, Burnett J.

Anomodon minor (Beauv.) Lindb. Not common. Widespread in the state.

SUBSTRATE: Bark of trees, occasionally on rocks. (Limestone and conglomerate.)
HABITAT: On bases of trees, around bases of boulders and foot of cliffs, in moist deciduous woods. Elevation 200 to 1600 feet.
REPRODUCTION: Spores ripe in late fall or winter. (13 specimens examined.)
Type locality: Eastern North America (Muhlenberg) probably Pennsylvania.
COUNTIES: Berks, Stonersville, 5983; Bucks, George School, Krout 5/7/10; Center, Phillipsburg, James (A); Franklin, Welsh Run, 4664; Lebanon, Rau (A); Lehigh, Fountain Hill, Wolle; McKean, Swiston Creek, Burnett 2864 (A); Monroe, Buck Hill Falls and Cresco, Browne; Northampton, Bath and Riverton, Schaeffer and Easton, Porter (A). (9 counties). Published, not seen: Cambria, James PC; Lancaster, Muhlenberg PC; Philadelphia, Byberry, James PC.

Anomodon rostratus (Hedw.) Schimp. Fairly common. Widespread.

SUBSTRATE: Rock surfaces. (Limestone, conglomerate and shale.) Bases of trees.
HABITAT: Open deciduous woods, pine-oak woods and old pastures overgrown by juniper. On boulders, in limestone quarries and sink-holes, shale bluffs, bases of trees and stream banks. Elevation 100 to 900 feet.
ASSOCIATES: Mixed with *Mnium* spp., overgrowing *Anomodon attenuatus* and in turn invaded by *Cladonia* spp.
REPRODUCTION: Capsules mature in September, open in October. (42 specimens examined, 4 fruiting.)
Type locality: Lancaster County, Pennsylvania.
COUNTIES: Bedford, Berks, Blair, Bradford, Bucks, Center, Chester, Franklin, Huntingdon, Lancaster, Lehigh, Monroe, Northampton, Philadelphia, York. (15 counties). Published, not seen: Delaware, Cresson TM and Wawa, Kaiser TM; McKean, Burnett PC.

Anomodon Rugelii (C. Mull.) Keissel. Rare. Bases of trees. Northern plateau region.

COUNTIES: McKean, Gates Hollow, Burnett 3003 (A); Monroe, Pocono Mountain, Porter 1869 (A); Pike, Rau (A). (3 counties). Published, not seen: Lancaster, Chiquesalunga Creek, Small PC.

Anomodon triste (Cesati) Sull. Rare.

SUBSTRATE: Soil, rock surfaces and bark.
HABITAT: Deciduous woods.
COUNTIES: Carbon, Onoko Glen, Wolle 6/73; Delaware, Newton township, Krout 7/4/08; Northampton, Bethlehem, Rau (A) and Easton, Porter 11/6/68 (A); Philadelphia, Manayunk, James 1860 (A) and Wissahickon, James (A). (4 counties). Published, not seen: Clearfield, James PC; Chester, James PC; Lancaster, Porter PC; McKean, Gates Hollow, Burnett J; Monroe, Analomink Creek, James PC.

Anomodon viticulosus (Hedw.) Hook. & Tayl. Rare. Rocky cliffs.

COUNTIES: Bucks, Narrowsville, James 11/1867 (A). Published, not seen: Franklin, Mercersburg, Porter PC; Lancaster, Tucquan, Small PC.

III. FABRONIACEAE

A. Gametophyte extremely small; leaf slightly denticulate to ciliate-dentate (occasionally entire) . . . . . 1. *Fabronia.*

A. Gametophyte larger; leaf entire to slightly denticulate . . . . . B.

B. Leaf costate . . . . . 2 *Anacamptodon.*

B. Leaf ecostate . . . . . 3. *Schwetzchkeopsis.*

1. FABRONIA Raddi.

A. Leaf strongly serrate . . . . . *ciliaris.*

A. Leaf slightly denticlulate to entire . . . . . *Ravenelii.*

Fabronia ciliaris (Brid.) Brid. Very rare. On bark of trees.

COUNTIES: Philadelphia, Bustleton, 6 6 66 (A). Published, not seen: Northampton, Bethlehem, Wolle PC.

Fabronia Ravenelii Sull. Very rare. On bark of trees.

COUNTIES: Franklin, Mercersburg, Porter PC; Northampton, James PC.

2. ANACAMPTODON Brid.

Anacamptodon splachnoides (Froehl.) Brid. Rare.

SUBSTRATE: In moist cavities in decaying wood.

HABITAT: Eastern hemlock forest. Elevation 150 to 1480 feet.

COUNTIES: McKean, Bradford, Burnett 140; Montgomery, Ringing Rocks Park, Krout 7/23/10; Northampton, Bethlehem, Rau (A); Philadelphia, Wissahickon, James 5/56 (A); Tioga, Mansfield, 4047. (5 counties). Published, not seen: Delaware, Smith TM; Lancaster, Muhlenberg PC; Lehigh, Rau PC.

3. SCHWETSCHKEOPSIS Broth.

Schwetschkeopsis denticulata (Sull.) Broth. Rare. On bark of trees.

COUNTIES: McKean, Lewis Run, Burnett 1543 (A); Monroe, Analomink, James 11/68 (A); Northampton, Bethlehem, Rau 1874 (A); Philadelphia, Schuylkill, James 7/53 (A). Published, not seen: Cambria, Cresson, James PC; Chester, New Garden, Michener PC; Delaware, James PC; Lehigh, Rau PC.

IV. ENTODONTACEAE

ENTODON C. Mull.

A. Leaf gradually and narrowly acuminate; segments of the inner peristome adherent to the teeth of the outer . . . . . *brevisetus.*

A. Leaf acute to apiculate; segments of the inner peristome free . . . . . B.

B. Leaves scarcely complanate . . . . . *seductrix.*

B. Leaves strongly complanate . . . . . C.

C. Plants robust; leafy stems and branches more than 1 mm. wide, peristome teeth not strongly striolate or papillose . . . . . *cladorrhizans.*

C. Plants slender; leafy stems and branches 1 mm. wide or less; peristome teeth striolate or papillose . . . . . *compressus.*

Entodon brevisetus (Hook. & Wils.) Jaeger & Sauerb. Rare. On bases of trees and limestone rocks.

COUNTIES: Chester, Landenberg, Krout 7/14/10. Published, not seen: Chester, New Garden, Michener PC; Elk, Bennett's Branch, McMinn PC; McKean, Burnett PC; Philadelphia, Bingham's PC.

Entodon cladorrhizans (Hedw.) C. Mull. Fairly common. Widespread.

SUBSTRATE: On rotten wood, tree trunks and soil.
HABITAT: All forest types. Elevation 150 to 2000 feet. (13 specimens.)
ASSOCIATES: With *Atrichum undulatum.*
Type locality: Lancaster, Pennsylvania.
COUNTIES: Adams, Berks, Bradford, Cameron, Columbia, Monroe, Philadelphia, Sullivan, Susquehanna, Warren. (10 counties). Published, not seen: Chester, Coventry, James PC; Delaware, Smith TM; Lancaster, Mount Hope, Small PC and Muhlenberg TM; Lehigh, James PC; McKean, Burnett PC; Northampton, James PC; Philadelphia, Wissahickon, Krout 8/5/08 TM and Kaiser 3/2/11 TM.

Entodon compressus (Hedw.) C. Mull. Not common.

SUBSTRATE: On soil, rotting logs and bases of trees.
HABITAT: Woodlands, marshy places and old pastures. Elevation 150 to 1300 feet.
ASSOCIATES: *Amblystegium serpens.*
(5 specimens.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Bradford, Greene Landing 4000a; Chester, Coventry, James 12/50 (A); Northampton, Easton, Porter 10/9/71 (A); Philadelphia, Wissahickon, Krout 9/7/10 (A) and Schuylkill, James 12/67 (A).

Entodon seductrix (Hedw.) C. Mull. Common. Widespread.

SUBSTRATE: Decaying logs, soil, humus and rock surfaces. (Limestone and quartzite.)
HABITAT: All forest types and old fields. Wooded slopes, banks of streams, stone walls, serpentine barrens and old quarries. Elevation 80 to 1820 feet.
REPRODUCTION: Capsules mature and shedding spores from October to January. (30 specimens, 10 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Adams, Berks, Bradford, Bucks, Center, Chester, Delaware, Elk, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, York. (14 counties). Published, not seen: Huntingdon, J; McKean, Burnett PC.
(*Entodon Sullivantii* (C. Mull.) Lindb. Excluded species. No specimens seen. Published, not seen: Philadelphia, Schuylkill River, James PC)

V. AMBLYSTEGIACEAE

A. Leaf-margin strongly differentiated . . . . . 4. *Sciaromium.*
A. Leaf-margin not differentiated . . . . . B.
B. Paraphyllia abundant and conspicuous . . . . . 5. *Cratoneuron.*
B. Paraphyllia not abundant or conspicuous . . . . . C.
C. Leaves slender, strongly costate and falcate-secund . . . . 10. *Drepanocladus.*
C. Leaves not both strongly costate and falcate-secund . . . . . D.
D. Leaf obtuse or rounded at apex . . . . . E.
D. Leaf acuminate and acute . . . . . F.
E. Costa subpercurrent; gametophyte not conspicuously pinnately branched 8. *Calliergon.*
E. Costa lacking or short and double; gametophyte large and pinnately branched 9. *Calliergonella.*
F. Leaf-cells 2–5 times as long as wide . . . . . G.
F. Leaf-cells 5–15 times as long as wide . . . . . H.
G. Gametophyte amphibious; cell-walls not usually thick; costa thin 2. *Amblystegium.*
G. Gametophyte aquatic; cell-walls thick, costa thick and heavy 3. *Hygroamblystegium.*

H. Leaf shortly acuminate with obtuse apex . . . . . 7. *Hygrohypnum.*
H. Leaf more slenderly acuminate with acute apex . . . . . I.
I. Leaves squarrose-spreading . . . . . 6. *Campylium.*
I. Leaves erect-spreading or flaccid (see also *Campylium polygamum.*) . . . . . 1. *Leptodictyum.*

1. LEPTODICTYUM (Schimp.) Warnst.

A. Leaf broadly ovate to ovate-lanceolate, shortly acuminate; gametophyte sometimes growing in wet places but not aquatic . . . . . *trichopodium.*
A. Leaf longer lanceolate, more slenderly acuminate; gametophyte usually aquatic *riparium.*

Leptodictyum riparium (Hedw.) Warnst. Rare. On rocks in water.

COUNTIES: Berks, Jacksonwald Pond, Wilkens 12/8/29 (A); Dauphin, Harrisburg, Porter 10/52 (A); Franklin, Mercersburg, Porter 1852 (A); Monroe, Tobyhanna, James 10/69 (A); Northampton, Bushkill, Porter 10/68 (A) and Pot Rock Pond, Porter 9/10/58 (A); Philadelphia, Wissahickon, James (A). (6 counties). Published, not seen: Bucks, Nockamixon, Kaiser TM and Oxford Valley, Tees 248 TM; Chester, James PC; Delaware, James PC; Lancaster, Lititz Spring, Porter PC.

Leptodictyum trichopodium (Schultz.) Warnst., var. *Kochii* (Bry. Eur.) Broth.

Very rare. No specimens seen. Published records: Center, Scotia J; Delaware, Swarthmore, Cresson 5/03 SMS; Lehigh, Center Valley, Tees 554 TM; McKean, Bradford, Burnett PC.

2. AMBLYSTEGIUM Bry. Eur.

A. Costa percurrent or nearly so, or excurrent . . . . . B.
A. Costa ending well below the apex, usually not far above the middle . . . . C.
B. Very slender, densely tufted; leaves finely and sharply denticulate; median leaf cells 6–10:1 . . . . . *compactum.*
B. Larger, leaves entire or at most obsoletely denticulate; median cells 3–6:1 *varium.*
C. Median leaf cells reaching 10:1 or longer . . . . . *Juratzkanum.*
C. Median leaf cells less than 8:1 . . . . . *serpens.*

Amblystegium compactum (C Mull.) Aust. Rare. On rock surfaces along stream banks. With *Mnium orthorhynchum* and a *Hepaticae*. Elevation 1400 feet.

COUNTIES: McKean, Gates Hollow, Burnett 1712 (A); Tioga, Niles Valley 4099. Published, not seen: Credited to Pennsylvania by L. Cheney (Bot. Gaz. 24:265).

Amblystegium Juratzkanum Schimp. Not common.

SUBSTRATE: Soil, stones and rotting wood.
HABITAT: Old orchard pasture on spring box, overgrown land and culverts. Elevation 300 to 1450 feet.
REPRODUCTION: Capsules open and shedding spores in April. (6 specimens.)
COUNTIES: Adams, Berks, Chester, Montgomery, Northampton, Warren. (6 counties). Published, not seen: Delaware, Broomall, Fogg 5/19/23 TM; Philadelphia, Chamoneoux, Tees 139, TM.

Amblystegium serpens (Hedw.) Bry. Eur. Commonest species in the state. Widespread.

SUBSTRATE: Moist substrates of all kinds. Soil, bark, stones and rotting logs. pH 6 to 7.
HABITAT: Deciduous forests. Stream banks, ravines, wet roadside woods, pond shores and bases of trees. Elevation 100 to 1300 feet.

REPRODUCTION: Immature capsules in March, open and shedding spores in late April. (21 specimens, 10 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Chester, Cumberland, Delaware, Lancaster, Lehigh, Monroe, Northampton, Philadelphia, York. (13 counties). Published, not seen: Cambria, Lloydsville, J.

Amblystegium varium (Hedw.) Lindb. Fairly common. Confined to the "cool" area.

SUBSTRATE: Rocks, rotting wood and humus.
HABITAT: Principally eastern hemlock formation. Exposed tree roots, shaded roadsides, ravines, shores of ponds and spring boxes. Elevation 100 to 1700 feet.
REPRODUCTION: Capsules open and shedding spores in late April and early May. (17 specimens, 7 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Adams, Berks, Chester, Delaware, Lehigh, McKean, Monroe, Northampton, Philadelphia, Sullivan, Tioga. (11 counties). Published, not seen: Bucks, Rau PC; Huntingdon, Spruce Creek, Porter PC; Lancaster, Muhlenberg TM and Lancaster, Tees 639 TM; Lebanon, Porter PC; Lehigh, Rau PC; Somerset, Ursina J; York, Porter PC.

Amblystegium varium (Hedw.) Lindb., var. **ovatum** Grout. Slender, julaceous or nearly so; stem leaves smaller, 1.2–1.5 mm. long, concave, round-ovate, abruptly and narrowly short acuminate.

COUNTIES: Philadelphia, Holmsburg 5903.

3. HYGROAMBLYSTEGIUM Loeske.

A. Costa excurrent . . . . . *noterophilum.*
A. Costa not excurrent . . . . . B.
B. Stem leaves entire, cordate-ovate to oblong-lanceolate, apex rather blunt; all forms aquatic . . . . . C.
B. Stem leaves narrower in outline, usually acute with a more slender acumen; growing in water or wet places . . . . . *irriguum.*
C. Stem leaves oblong-ovate to broadly oblong-lanceolate, 1–2 mm. in length, gradually and evenly narrowed to a rather blunt apex . . . . . *fluviatile.*
C. Stem leaves ovate to cordate-ovate, usually less than 1.2 mm. long, more abruptly narrowed to a distinct acumination . . . . . *orthocladon.*

Hygroamblystegium fluviatile (Hedw.) Loeske. Fairly common. Widespread.

SUBSTRATE: On stones and soil in and along streams.
HABITAT: All forest types. Streams and stream banks in dark cool ravines and hollows. Elevation 100 to 760 feet.
ASSOCIATES: *Eurhynchium rusciforme.*
REPRODUCTION: Capsules open and shedding spores in May. (15 specimens, 5 fruiting.)
COUNTIES: Berks, Chester, Clinton, Lycoming, McKean, Monroe, Philadelphia, Schuylkill. (8 counties). Published, not seen: Pike, outlet of East Branch Pond, Rau PC.

Hygroamblystegium fluviatile (Hedw.) Loeske, var. **ovatum** Grout.

Type locality: Near West Chester, Chester county, Pennsylvania, F. Windle 5/15/04. Grout (1931) 3:74.

Hygroamblystegium irriguum (Wils.) Loeske. Rare.

SUBSTRATE: Soil and rocks at edge of water.
HABITAT: Wooded streams and ponds.
REPRODUCTION: Capsules mature and spores present in May. (7 specimens.)

COUNTIES: Adams, Knoxlyn 5845; Berks, Wernersville, Williams 5/9/08; Delaware, Williamson School, Lowe 6/3/99; Franklin, Orrstown 6007; Lehigh, Allentown, Pretz 13613 (A); Northampton, Bethlehem, Rau (A); Philadelphia, Wissahickon, Kaiser 5/16/10 and Shawmont, Krout 6/14/99. (7 counties). Published, not seen: Bedford, Hyndman J; Bucks, Point Pleasant, York 5/32, TM and Lumberville, Long 582, TM; Cambria, Cresson and Johnstown, James PC; Huntingdon, Porter PC; Lancaster, Muhlenberg, TM; Monroe, Water Gap, Wood, PC.

Hygroamblystegium noterophilum (Sull.) Warnst. Rare. In streams and springs containing lime.

Type locality: Franklin County, Pennsylvania.
COUNTIES: Franklin, Mercersburg, Porter (A); Lancaster, Lititz Spring, Porter 5/65 (A) and Musci Appal. Austin 385, Porter (A); Northampton, Monocacy, Rau 4/72 (A). (3 counties.)

Hygroamblystegium orthocladon (Beauv.) Grout. Common. Widespread.

SUBSTRATE: Rocks and sandy soil. pH 6 to 7.
HABITAT: Hardwood forests. Wet cliffs, streams and old dam breast. (18 specimens.)
COUNTIES: Berks, Bucks, Cambria, Chester, Delaware, Lancaster, McKean, Montgomery, Northampton, Philadelphia, York. (11 counties.)

4. Sciaromium Mitt.

Sciaromium Lescurii (Sull.) Broth. Rare. On wet rocks.

COUNTIES: Lancaster, Safe Harbor, Porter 7/57 (A); Lehigh (A); Northampton, Bushkill Gap, Porter 11/16/68 (A); York, Opposite Marietta, Porter 7/11/57 (A). (4 counties). Published, not seen: Carbon, Rau PC; Delaware, Springfield, Krout 9/08; Luzerne, Rau PC; Philadelphia, Wissahickon, James PC.

5. Cratoneuron (Sull.) Roth.

Cratoneuron filicinum (Hedw.) Roth. Rare. Streams and wet areas, preferably where limestone is present.

COUNTIES: Bucks, Nockamixon, Rau 7/74 (A); Huntingdon, Spruce Creek, Porter (A); Lancaster, Dillerville Swamp, Porter 2/57 (A). (3 counties). Published, not seen: Northampton, Monocacy, Rau PC.

6. Campylium (Sull.) Mitt.

A. Leaves strongly squarrose . . . . . B.
A. Leaves not noticeably squarrose . . . . . D.
  B. Leaves strongly costate . . . . . *chrysophyllum.*
  B. Leaves without costa or with costa short and double . . . . . C.
C. Plants very slender; alar cells not conspicuously enlarged or inflated *hispidulum.*
C. Plants stouter; alar cells conspicuously enlarged and inflated . . . . *stellatum.*
  D. Stem leaves cordate-ovate, abruptly slenderly acuminate; dioicous . *radicale.*
  D. Stem leaves broadly lanceolate, gradually narrowed to a very slender acumination; monoicous . . . . . *polygamum.*

Campylium chrysophyllum (Brid.) Bryhn. Common. Widespread.

SUBSTRATE: Soil, logs and humus on rock surfaces.
HABITAT: All forest types and old fields. Shaded paths, stream banks, wet cliffs and lake shores. Elevation 100 to 2000 feet.
ASSOCIATES: *Eurhynchium serrulatum.*
REPRODUCTION: Capsules open and shedding spores in May. (17 specimens, 3 fruiting.)

COUNTIES: Adams, Bucks, Chester, Columbia, Lancaster, McKean, Monroe, Northampton, Philadelphia, Susquehanna, Tioga, York. (12 counties). Published, not seen: Carbon PC; Delaware, Brinton's Bridge, Kaiser 4/22/22 TM and Lima Tees 678 TM; Lehigh PC; Montgomery, Zieglersville, Tees 526 TM; Pike, PC.

Campylium hispidulum (Brid.) Mitt. Fairly common. Widespread.

SUBSTRATE: Soil, old logs and stone walls. pH 5 to 7.
HABITAT: Hardwood forests. Stream banks, road banks, wall of bridge, bases of trees and wooded slopes.
REPRODUCTION: Capsules mature in May. (12 specimens, 5 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Bucks, Center, Chester, Delaware, Northampton, Philadelphia, York. (7 counties). Published, not seen: Cambria, James PC; Center, Scotia J; Lancaster, Porter and Small PC and Muhlenberg TM; Lehigh, Rau PC; McKean, Burnett PC; Monroe, Pocono, James PC; Montgomery, Pottstown, Kaiser 3/22/11 SMS.

Campylium hispidulum (Brid.) Mitt., var. **Sommerfeltii** (Myrin) Lindb.

COUNTIES: Bucks, Narrowsville, James 7/71 (A).

Campylium polygamum (Bry. Eur.) Bryhn. Rare.

SUBSTRATE: Humus on wet rocks.
HABITAT: Beech-maple woods on lake shore. Elevation 100 to 2000 feet.
COUNTIES: Cambria, Allegheny Mountains, James 6/58 (A); Philadelphia, Wissahickon, James 7/52 and 8/64 (A); Susquehanna, Gelatt 3871.

Campylium radicale (Beauv.) Grout. Rare.

COUNTIES: Lehigh, Black River, Rau (A); Northampton, Bethlehem, Rau 6/22/73 (A); Philadelphia, James 6/89 (A) and Wissahickon 6/1/59 (A). Published, not seen: Lancaster, Conewago, Small PC; McKean, Bradford, Burnett J; Pike, Rau PC.

Campylium stellatum (Hedw.) Lange & C. Jens. Rare.

COUNTIES: Lancaster, Dillerville, Porter 6/66 (A); Lehigh, Rau (A); Northampton, Bingens, Rau 5/74 (A). Published, not seen: Chester, "Flora Cestrica" PC; Delaware, Glenolden, Krout 4/03 TM; McKean, Burnett PC.

7. HYGROHYPNUM Lindb.

A. Alar cells large and conspicuous, clear, hyaline or colored, forming distinct decurrent auricles; outer layer of stem cells much enlarged . . . . . B.

A. Alar cells thick-walled, less distinctly inflated, granulose to subopaque, often colored; outer layer of stem cells not enlarged . . . . . *palustre.*

B. Alar cells hyaline and thin-walled; costa usually reaching the middle of the leaf; dioicous . . . . . *ochraceum.*

B. Alar cells usually colored and thick-walled except the outer row or two, which are usually thin-walled and often hyaline; costa double, short and faint; monoicous . . . . . *eugyrium.*

Hygrohypnum eugyrium (Bry. Eur.) Loeske. Rare. "Cool" mountainous area.

SUBSTRATE: Rocks in stream.
HABITAT: Hemlock forest. Streams and spring outlets.
COUNTIES: Carbon, Onoko Glen, Wolle 6/74; Huntingdon, Porter (A); McKean, Bennett Brook, Burnett 7/97; Monroe, Delaware Water Gap, M. R. 7/60; Snyder, Troxelville 5481. Published, not seen: Luzerne, Rau PC.

Hygrohypnum ochraceum (Turn.) Loeske. Rare.

COUNTIES: Lehigh, Rau (A); Monroe, Pocono Forks, James 11/68 (A). Published, not seen: Cambria, Cresson, James PC; Carbon, Mauch Chunk, James PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC; Pike, Rau PC.

Hygrohypnum palustre (Hedw.) Loeske. Very rare.
COUNTIES: Huntingdon, Porter (A). Published, not seen: Carbon, Rau PC; McKean, Burnett PC.

8. CALLIERGON (Sull.) Kindb.

A. Costa extending to the middle or a little above . . . . . B.
A. Costa subpercurrent . . . . . C.
B. Slender, yellowish-green to straw-color; stem leaves usually suberect and imbricated when dry, oblong to ovate-oblong . . . . . *stramineum.*
B. More robust, brighter green; stem leaves spreading to erect-spreading, broadly cordate-ovate to suborbicular . . . . . *Richardsoni.*
C. Slender, simple or sparingly branched; alar cells gradually enlarged . *cordifolium.*
C. Robust, profusely branched; alar cells abruptly enlarged . . . . . *giganteum.*

Calliergon cordifolium (Hedw.) Kindb. Rare. Swamps, northern part of the state.
COUNTIES: Lehigh, Rau (A); Monroe, Pocono Mountain, Porter 6/67 (A); McKean, Fosters Branch, Burnett 735 (A). Published, not seen: Bucks, Rau PC and Penn Valley, Krout 5/10/99 TM; Cambria, Lloydsville, J; Delaware, Smith TM; Lancaster, Dillerville, Small 7/25/94, Northampton, Rau PC; Pike, Wynne (1945).

Calliergon giganteum (Schimp.) Kindb. Very rare. Swamps.
COUNTIES: Lancaster, Dillerville, Porter (A).

Calliergon Richardsoni (Mitt.) Kindb. Rare.
Published, not seen: Lancaster, Dillerville Swamp, 7/25/94, Wynne (1945).

Calliergon stramineum (Brid.) Kindb. Very rare. Swamps.
COUNTIES: Monroe, Tunkhannock, Porter 7/21/60 (A).

9. CALLIERGONELLA Loeske

A. Alar cells abruptly inflated, thin-walled and usually hyaline, forming decurrent auricles . . . . . *cuspidata.*
A. Alar cells somewhat enlarged but not thin-walled nor forming auricles . *Schreberi.*

Calliergonella cuspidata (Brid.) Loeske. Rare.
SUBSTRATE: Swamps and marshy ground.
COUNTIES: Lancaster, Dillerville, Porter (A); Northampton, Bingen Swamps, Rau 6/74 (A). Published, not seen: Lehigh, Rau PC; McKean, East Branch, Teina Swamp, Burnett J; Snyder, between Shamokin Dam and Richfield J.

Calliergonella Schreberi (Bry. Eur.) Grout. Fairly common. "Cool" mountainous area, chiefly.
SUBSTRATE: Soil and decaying logs.
HABITAT: Principally in eastern hemlock formation. Swamps, shaded slopes, road banks and ditches. Elevation 100 to 2100 feet.
ASSOCIATES: *Mnium affine*, *Leucobryum glaucum*, *Pohlia nutans*. Several times collected growing under *Lycopodium* spp. (21 specimens).
COUNTIES: Bedford, Berks, Bucks, Dauphin, Lancaster, Lebanon, Lehigh, Luzerne, Northampton, Philadelphia, Potter, Sullivan, Warren, Wayne. (14 counties). Published, not seen: Cameron, Hunt's Run, Burnett J; Carbon, Rau PC; Chester, James PC; Delaware, James PC; Elk, McMinn PC; Huntingdon, Porter PC; McKean, Burnett PC; Monroe, Britton PC and Barett Township, Moldenke 3362; Pike, Garber PC; Potter, Eulalie Township, Moldenke 16213; Somerset, Allegheny Mountains, Patterson J.

10. DREPANOCLADUS (C. Mull.) Roth.

A. Leaves entire; alar cells usually greatly enlarged and inflated . . . . . B.
A. Leaves, some or all plainly dentate . . . . . C.
B. Costa stout; enlarged auricular cells not reaching the costa, their cell walls usually somewhat thickened and colored when old . . . . . *Sendtneri.*
B. Costa more slender, enlarged and inflated auricular cells often reaching the costa, not thickened, rarely much colored . . . . . *aduncus.*
C. Leaves strongly plicate even when moist . . . . . *uncinatus.*
C. Leaves not plicate, alar cells more or less inflated . . . . . *fluitans.*

Drepanocladus aduncus (Hedw.) Warnst. Rare.

COUNTIES: Franklin, Mercersburg, Porter 1852 (A); Northampton, Bethlehem, Rau (A); York, opposite Marietta, Porter (A). Published, not seen: Bucks, Nockamixon, Kaiser SMS; Lancaster, Porter PC.

Drepanocladus aduncus (Hedw.) Warnst., var. **Kneiffi** (Bry. Eur.) Warnst.

COUNTIES: Monroe, Delaware Water Gap, Austin 10/71 (A). Published, not seen: Carbon, Wolle PC; Lancaster, Conewago, Small PC; Luzerne, Rau PC.

Drepanocladus fluitans (Hedw.) Warnst. Rare. Usually in flowing water.

COUNTIES: Chester, Williston Township, Windle 4/22/08; Delaware, Tinicum Island, Krout 7/3/09; Lancaster, Smithville Swamp, Small 10/31/91 (A); Lehigh, Rau (A); Luzerne, Hazelton, Wolle 7/75; Monroe, Tobyhanna, James 11/68 (A); Delaware Water Gap, Austin 10/71 (A) and Porter 1868 (A). (6 counties). Published, not seen: Carbon, Rau PC; Center, Bear Meadow, Porter PC; McKean, West Branch, Burnett J; Pike, Rau PC.

Drepanocladus Sendtneri (Schimp.) Warnst., var. **Wilsoni** (Schimp.) Monkem. Very rare.

COUNTIES: Monroe, Pocono Mountain, Porter (A).

Drepanoclaudus uncinatus (Hedw.) Warnst. Not common.

SUBSTRATE: Rotting logs above water level, but in moist situations.
HABITAT: Swamps and wet wooded hillside. Elevation 100 to 2000 feet.
COUNTIES: McKean, Corydon 4446 and Rew 5996; Monroe, Mount Pocono, Kaiser 7/9/10; Philadelphia, Manayunk, James 6/51 (A); Pike, Elbow Swamp, Rau 8/73 (A). (4 counties). Published, not seen: Cambria, James PC; Chester, Michener PC; Delaware, Smith PC; Huntingdon, Porter PC; Lancaster, Dillerville, Porter PC; Northampton, Bethlehem, Rau PC.

VI. BRACHYTHECIACEAE

A. Leaf conspicuously papillose beneath by projecting cell-angles . . . 1. *Bryhnia.*
A. Leaf not conspicuously papillose beneath . . . . . B.
B. Leaf large, concave, spoon-shaped, abruptly acuminate . . . 3. *Cirriphyllum.*
B. Leaf seldom plicate or, if so, more gradually acuminate . . . . . C.
C. Apical cells of branch leaves often shorter and broader than the rest; costa often ending in a spine beneath; operculum long-rostrate . . 2. *Eurhynchium.*
C. Apical cells of branch leaves not noticeably different; costa not ending in a spine beneath; operculum conic to conic-rostrate . . . . . D.
D. Gametophyte small: calyptra hairy; inner peristome adherent to outer; seta rough . . . . . 6. *Homalotheciella.*
D. Gametophyte larger; calyptra smooth; inner peristome separate from outer; seta smooth or rough . . . . . E.

E. Erect symmetric and cylindrical capsules, lacking cilia in the peristome
4. Chamberlainia.

E. More or less cernuous and unsymmetric capsules; cilia well developed
5. Brachythecium.

1. BRYHNIA Kaurin.

A. Branch-leaf broad, shortly acuminate; apex twisted . . . . . *novae-angliae.*

A. Branch-leaf ovate-lanceolate, more slenderly acuminate; apex not twisted
graminicolor.

Bryhnia graminicolor (Brid.) Grout. Fairly common. Widespread.
SUBSTRATE: Rocks, soil and rotting wood.
HABITAT: All forest types. Steep wooded slopes and shaded ravines. Elevation 100 to 1400 feet. (13 specimens).
Type locality: Pennsylvania, Muhlenberg.
COUNTIES: Berks, Bucks, Huntingdon, Lancaster, Northampton, Philadelphia, Tioga, York. (8 counties). Published, not seen: Delaware, Smith TM; Franklin, Mercersburg, Porter PC; Lehigh, Rau PC; McKean, Bradford, Burnett PC; Pike PC.

Bryhnia novae-angliae (Sull. & Lesq.) Grout. Fairly common. Widespread.
SUBSTRATE: Soil and decaying logs.
HABITAT: Hardwood forests. Moist woodlands, stream banks, log in spring, swampy area and on serpentine barrens. (13 specimens.)
COUNTIES: Berks, Chester, Delaware, Lancaster, Lehigh, Monroe, Northampton, Philadelphia, Sullivan. (9 counties). Published records not seen: McKean, Burnett PC; Montgomery, Pottstown, Kaiser 3/22/11 SMS; Pike, Rau PC; York, Porter PC.

2. EURHYNCHIUM Bry. Eur.

A. Apical cells of branch leaves oblong-rhomboidal to circular . . . . . B.

A. Apical cells of branch leaves not materially different from the median cells
serrulatum.

B. Seta rough . . . . . *hians.*

B. Seta smooth . . . . . C.

C. Aquatic, on stones in streams . . . . . *rusciforme.*

C. Terrestrial, usually growing on soil . . . . . *strigosum.*

(*Eurhynchium diversifolium* (Schleich.) Bry. Eur. Excluded species. Range is western North America. Published record: Northampton, Bethlehem, Rau PC.)

Eurhynchium hians (Hedw.) Jaeger & Sauerb. Fairly common. Widespread.
SUBSTRATE: Soil.
HABITAT: All forest types. Moist areas in woods, shores of ponds and streams.
ASSOCIATES: *Climacium dendroides.* (7 specimens.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Bradford, Bucks, Lebanon, Monroe, Philadelphia, York. (6 counties). Published, not seen: Cambria, Cresson, Porter PC; Chester, Coventry, James PC; Delaware, Smith, PC; Elk, Bennett's Branch, McMinn PC; Franklin, Mercersburg, Porter PC; Lancaster, Porter PC and Muhlenberg TM; Lehigh, Rau PC; McKean, Burnett PC.

Eurhynchium rusciforme (Neck.) Milde. Fairly common. Widespread.
SUBSTRATE: Wet rocks and soil. pH6 to 7.
HABITAT: Eastern hemlock formation. Stream banks, wet cliffs and swamps. Elevation 150 to 1400 feet. (17 specimens.)
COUNTIES: Bradford, Bucks, Center, Clinton, Lehigh, McKean, Monroe, Montgomery,

Philadelphia, Tioga, York. (11 counties). Published, not seen: Cambria, Cresson, James PC; Chester, Coventry, James PC; Lancaster, Chickies, Porter and Mount Hope, Small PC; Northampton, Bethlehem, Rau PC.

Eurhynchium serrulatum (Hedw.) Kindb. Common. Widespread.

SUBSTRATE: Soil, rotting wood and humus.
HABITAT: All forest types and old fields. Wooded hillsides, stream banks, roadside ditches and banks, overgrown lanes and ravines. Elevation 10 to 2000 feet.
ASSOCIATES: *Dicranum* spp., *Mnium affine*.
REPRODUCTION: Capsules mature in September and October. (54 specimens, 16 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Center, Chester, Clinton, Delaware, Lancaster, McKean, Monroe, Montgomery, Northampton, Philadelphia, Potter, Schuylkill, Sullivan, York. (18 counties). Published, not seen: Cambria, Cresson, James PC; Lehigh, Rau PC; Pike, Rau PC.

Eurhynchium strigosum (Hoffm.) Bry. Eur., var. **praecox** (Hedw.) Husnot. Rare.

In road cut on north facing bank, pH7. York county, Tildens 6019. Published, not seen: Lancaster, Muhlenberg PC.

Eurhynchium strigosum (Hoffm.) Bry. Eur., var. **robustum** Roll. Common. "Cool" mountainous area.

SUBSTRATE: Soil, decaying wood, humus and rock surfaces covered with litter.
HABITAT: Eastern hemlock formation. Stream banks, hillsides, bases of trees, ravines and stone walls. Elevation 100 to 1400 feet.
REPRODUCTION: Capsules mature and closed in September and October. (20 specimens.)
COUNTIES: Berks, Bucks, Clinton, Delaware, Huntingdon, Lehigh, McKean, Monroe, Northampton, Philadelphia, Potter, Tioga, York. (13 counties). Published, not seen: Chester, Coventry, James PC; Elk, McMinn PC; Lancaster, Muhlenberg TM.

3. CIRRIPHYLLUM Grout.

A. Leaf with a long, filiform acumination . . . . . *piliferum*
A. Leaf shortly acuminate . . . . . *Boscii.*

Cirriphyllum Boscii (Schwaegr.) Grout. Common. Widespread.

SUBSTRATE: Soil and rock surfaces. (Sometimes limestone.) pH4 to 7.5.
HABITAT: Deciduous forests. Stream and pond shores, old fields, thickets and serpentine barrens. Elevation 150 to 1300 feet.
ASSOCIATES: *Mnium affine*, *Hypnum* spp., and species of *Cladonia*. (43 specimens.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Chester, Columbia, Delaware, Franklin, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, York. (15 counties). Published, not seen: Cambria, Porter PC; Huntingdon, Pennsylvania Furnace, J; Monroe, Mount Pocono, Britton PC.

Cirriphyllum piliferum (Hedw.) Grout. Rare.

SUBSTRATE: Soil.
COUNTIES: McKean, Langmade, Burnett 2869; Monroe, Delaware Water Gap, James 11/68 (A); Philadelphia, Wissahickon, James 2/52 (A). Published, not seen: Delaware, Smith TM; Elk, Benezette PC.

4. CHAMBERLAINIA Grout.

A. Plants as robust as *Brachythecium oxycladon*, and resembling it when sterile *acuminata.*
A. Plants more slender . . . . . *crytophylla.*

Chamberlainia acuminata (Schwaegr.) Grout. Not common. Soil and rotting wood in shaded areas. (9 specimens.)

Type locality: Lancaster, Pennsylvania.
COUNTIES: Center, Chester, McKean, Northampton, Philadelphia, York. (6 counties). Published, not seen: Bucks, Kintnersville, True 6/31/31 TM; Clearfield, Phillipsburg, James PC; Franklin, Mercersburg, Porter PC; Lancaster, Conewago, Small PC and Muhlenberg TM; Lehigh, Center Valley, Tees 555 TM; Montgomery, Kulpsville, Tees 250 TM.

Chamberlainia crytophylla (Kindb.) Grout. Rare.
COUNTIES: McKean, Riverside Park, Burnett 2774 (A).

5. BRACHYTHECIUM Bry. Eur.

A. Costa percurrent or nearly so . . . . . *populeum.*
A. Costa extending ½–⅔ the length of the leaf . . . . . B.
B. Seta smooth . . . . . C.
B. Seta rough above, smooth below . . . . . G.
C. Capsules suberect, 3–4:1 . . . . . *oxycladon.*
C. Capsules strongly inclined and unsymmetric 2–3:1 . . . . . D.
D. Leaves not plicate or striate; stem leaves gradually narrowed from base to apex . . . . . *acutum.*
D. Leaves plicate or striate . . . . . E.
E. Stem leaves lanceolate, 0.6 mm. broad at base gradually and evenly narrowed to a slender acumination . . . . . *flexicaule.*
E. Stem leaves ovate, at least 1 mm. broad at base, more abruptly narrowed to a slender acumination . . . . . F.
F. Stem leaves ovate-lanceolate, 2–2.5 by 0.8–1.1 mm., median leaf cells 10:1 *salebrosum.*
F. Stem leaves triangular-ovate, 1.2–0.8 mm., median cells 4–6:1 . . *digastrum.*
G. Leaves plicate, long-acuminate, branch leaves strongly serrate . . . . *campestre.*
G. Leaves not plicate, shorter-acuminate, branch leaves entire or serrate . *flagellare.*
H. Secondary stems often dendroid, stem leaves ovate and very sharp-pointed with enlarged and inflated alar cells . . . . . *rivulare.*
H. Not dendroid; stem leaves slenderly acuminate . . . . . I.
I. Slender, leaves somewhat secund, stem leaves lanceolate . . . . . *velutinum.*
I. Robust, leaves not secund, stem leaves ovate to triangular-ovate . . . . . J.
J. Complanate-foliate; leaves cordate-triangular and strongly and widely decurrent; cilia of inner peristome appendiculate . . . . . *Starkei.*
J. Not complanate; leaves ovate and less strongly decurrent; cilia not appendiculate . . . . . *rutabulum.*

Brachythecium acutum (Mitt.) Sull. Rare. No specimens seen. Northern species.
Published, not seen: Lehigh, Rau PC; McKean, Burnett PC; Monroe, Water Gap, Austin PC; Montgomery, Ambler, Kaiser 11/18/16 SMS; Northampton, Rau PC.

Brachythecium campestre Bry. Eur. Rare. Northern species.
COUNTIES: Bucks, Morrisville, James 9/50 (A); Elk, Benezette, James 11/68 (A). Published, not seen: McKean, Bennett Brook and Quintuple, Burnett J; Monroe, Tobyhanna, Rau PC; Northampton, Bethlehem, Rau PC.

Brachythecium digastrum C. Mull. & Kindb. Very rare. Rocks on creek bank.
Capsules open and closed in April. Elevation 400 feet. pH6.
COUNTIES: Adams, Hampton 5992.

Brachythecium flagellare (Hedw.) Jennings. Common. Widespread.

SUBSTRATE: Rocks and soil along streams. Semi-aquatic. pH7.
HABITAT: Alluvial woods. Stream banks, pastures and moist wooded slopes. Elevation 100 to 1600 feet. (20 specimens.)
COUNTIES: Berks, Bucks, Center, Chester, Delaware, Lehigh, McKean, Monroe, Northampton, Philadelphia, Pike, Sullivan, Susquehanna. (13 counties). Published, not seen: Bedford, Hyndman J; Lancaster, Rock Hill and Tucquan, Small PC; Montgomery, Fraser's Bog, Wismer 1/29/33 TM.

Brachythecium flexicaule Ren. & Card. Rare. Northern species. On rotten stump at 1900 feet in hardwood forest. pH5. Capsule closed in September.

COUNTIES: McKean, Rew 5984. Published, not seen: Lancaster, Muhlenberg PC; McKean, Burnett PC.

Brachythecium oxycladon (Brid.) Jaeger & Sauerb. Common. Widespread.

SUBSTRATE: Soil and humus covered rocks.
HABITAT: All forest types. Dry rocks, grassy road banks, stream banks and serpentine barrens.
REPRODUCTION: Capsules mature and closed in October and November. (12 specimens, 4 fruiting.)
Type locality: Lancaster, Pennsylvania (Ludwig.)
COUNTIES: Bucks, Franklin, Lancaster, McKean, Monroe, Montgomery, Northampton, Philadelphia, Schuylkill, York. (10 counties). Published, not seen: Berks, Wernersville, Tees 270 TM; Delaware, Smith TM.

Brachythecium populeum (Hedw.) Bry. Eur., var. **ovatum**, Grout. Rare. On stone walls and boulders in open woodlands.

ASSOCIATES: *Bryum argenteum*.
COUNTIES: Berks, Stonersville 5990; Philadelphia, Wissahickon, Githens 494 (A) and Holmesburg, James 4/60 (A); York, Wrightsville, James 8/24/61. (3 counties.) Published, not seen: Delaware, Smith TM.

Brachythecium rivulare Bry. Eur. Fairly common. Widespread.

SUBSTRATE: Silt, rocks and rotting wood in stream beds or along the shore. pH 6–7.
HABITAT: Alluvial hardwoods. Ravines, wet cliffs, stream banks, falls and dam breast. Elevation 100 to 1448 feet.
ASSOCIATES: *Atrichum undulatum* and *Thuidium delicatulum*.
REPRODUCTION: Capsules mature in November. (18 specimens, 2 fruiting.)
COUNTIES: Adams, Bucks, Delaware, Lehigh. Luzerne, McKean, Monroe, Northampton, Philadelphia, Susquehanna, Wyoming, York. (12 counties). Published, not seen: Cambria, Cresson, James PC; Chester, Downingtown, Tees 149 & 159 TM; Lancaster, Mount Hope, Small PC; Montgomery, Arcola, Tees 517 TM.

Brachythecium rutabulum (Hedw.) Bry. Eur. Common. Northern species reaching its southern limits in Pennsylvania and New Jersey.

SUBSTRATE: Soil and stones in moist places. Less frequent on roots and rotting wood.
HABITAT: More frequent in the eastern hemlock formation, but occurs in oak-hickory woods. 150 to 2000 feet.
REPRODUCTION: Capsules mature and closed in October. Open in November and December. (23 specimens, 14 fruiting.)
COUNTIES: Berks, Bradford, Chester, Elk, Lehigh, Monroe, Montgomery, Northampton, Philadelphia, Susquehanna, Warren, York. (12 counties). Published, not seen: Bucks, James PC; Delaware, James PC; Franklin, Mercersburg, Porter PC; Lancaster, Porter PC and Bartsville, Jackson 2/16 SMS; Philadelphia, Rau PC.

Brachythecium salebrosum (Web. & Mohr.) Bry. Eur. Fairly common. Widespread.
SUBSTRATE: Soil and rotting wood.
HABITAT: All forest types. Stream banks, wooded slopes, top of decaying stumps and logs, lawns. Elevation 100 to 1700 feet.
ASSOCIATES: *Mnium punctatum, Anomodon attenuatus.*
REPRODUCTION: Capsules closed and mature in September and October. (12 specimens, 4 fruiting.)
COUNTIES: Adams, Chester, Lehigh, McKean, Monroe, Philadelphia, Potter, Tioga, Venango. (9 counties). Published, not seen: Bucks, Brownsburg, Tees 353 TM; Clinton, Renovo J; Delaware, Smith TM; Elk, McMinn PC; Lancaster, Porter PC and Muhlenberg TM; Northampton, Bethlehem, Rau PC; York, Porter PC.

Brachythecium Starkei (Brid.) Bry. Eur. Not common. "Cool" mountainous area.
SUBSTRATE: Soil.
HABITAT: Eastern hemlock formation. Swamps and wet road banks. Elevation 1500 to 1700 feet.
ASSOCIATES: *Rhodobryum roseum.*
REPRODUCTION: Capsules closed and mature in September.
COUNTIES: Elk, Benezette, McMinn 11/68 (A); Monroe, Tobyhanna, James 10/69 (A); Potter, Sweden Valley 4276; Warren, Sugar Grove 6004. (4 counties.) Published, not seen: Carbon, Rau PC; McKean, Burnett PC; Pike, Rau PC.

Brachythecium velutinum (Hedw.) Bry. Eur. Rare. Northern species.
COUNTIES: Susquehanna, St. Joseph 3917 & 3918; York, Porter (A). Published, not seen: Lancaster, Small PC; McKean, Burnett PC; Philadelphia, Wissahickon, Krout 9/7/10 TM.

6. HOMALOTHECIELLA Card.

Homalotheciella subcapillata (Hedw.) Card. Rare. Widespread.
SUBSTRATE: Tree trunks and rock surfaces.
COUNTIES: Delaware, Llewellyn, Krout 5/5/06; Lancaster, Cedar Hill, Porter 12/10/61 (A); Montgomery, Pottstown, Kaiser 3/22/11; Northampton, Hellertown, Wolle 11/73 and Easton, Porter 11/67 (A); Philadelphia, Bartram's Gardens, James 10/50 (A) and near Schuylkill, James 12/55 (A). (5 counties). Published, not seen: Chester, Warwick Furnace, James PC; Elk, McMinn PC.

VII. PLAGIOTHECIACEAE

PLAGIOTHECIUM Bry. Eur.

A. Mostly very slender plants, light yellowish green to whitish, glossy; leaves little or not at all decurrent; median leaf cells narrowly linear, alar little or not at all differentiated; capsules not plicate . . . . . B.

A. Usually larger, darker green; leaves decurrent; leaf cells wider; alar clearly differentiated; capsules often plicate . . . . . H.

B. Leaves complanate . . . . . C.

B. Leaves not complanate, entire . . . . . *pulchellum.*

C. Leaves entire, scarcely a trace of serration on any leaf; cortical cells of stem very large; plants of cold ravines, growing mostly in moist crevices of ledges *Mullerianum.*

C. Leaves more or less serrate . . . . . D.

D. Leaves strongly serrate in the upper half . . . . . E.

D. Leaves serrulate at or near apex only . . . . . G.

E. Plants very slender, usually growing on decayed wood or humus, sometimes on soil . . . . . *turfaceum.*

E. Plants larger, growing on earth and stones . . . . . F.

F. Plants dark green, leaves distant, apex usually bluntish . . . . *geophilum.*
F. Plants lighter green, usually yellowish and glossy, leaves closer, not blunt *deplanatum.*

G. Plants light yellowish-green, costa very faint or none; growing chiefly in the lowlands from Long Island southward . . . . . *micans.*
G. Plants not yellowish, often dark green; costa evident, often reaching middle of leaf; growing in cool ravines and on mountains . . . . . *elegans.*
H. Leaves not complanate, squarrose-spreading; capsule strongly striate *striatellum.*
H. Leaves complanate . . . . . I.

I. Leaves slenderly acuminate; capsules erect and symmetric; peristome without cilia . . . . . *laetum.*
I. Leaves acute to somewhat acuminate; capsules more or less inclined and unsymmetric; peristome perfect . . . . . J.
J. Not complanate or only slightly so . . . . . *Roeseanum.*
J. Conspicuously complanate . . . . . K.

K. Plants dingy or yellowish green; leaves shrunken when dry, dioicous; operculum rostrate . . . . . *sylvaticum.*
K. Plants bright green; monoicous; operculum conic . . . . . *denticulatum.*

Plagiothecium denticulatum (Hedw.) Bry. Eur. Commonest species. Widespread.
SUBSTRATE: On soil, humus, rotten wood and stones. pH4 to 5.
HABITAT: All forest types. Wooded hillsides, road banks, bases of trees and shrubs, swamps and serpentine barrens. Elevation 200 to 2000 feet.
ASSOCIATES: *Mnium cuspidatum*, *Polytrichum* spp., and *Hypnum imponens.*
REPRODUCTION: Capsules mature and closed in May. Open and shedding spores from June to September. Empty capsules remain on the plants until November. (31 specimens, 14 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Cambria, Clinton, Delaware, Huntingdon, Lancaster, Lebanon, Lehigh, McKean, Monroe, Montgomery, Northampton, Pike, Schuylkill. Somerset, Sullivan, Tioga, Warren, Wayne, York. (23 counties). Published, not seen: Chester, James PC; Clearfield, Potterdale J and Dubois, Moldenke 4412; Franklin, Porter PC; Philadelphia, Wissahickon, Tees 80 TM and James PC.

Plagiothecium deplanatum (Sull.) Grout. Fairly common. Widespread.
SUBSTRATE: Soil, humus and rocks.
HABITAT: Deciduous forests. Wooded hillsides, ravines, stream banks, rocks covered with humus and bases of trees.
ASSOCIATES: *Mnium cuspidatum.*
REPRODUCTION: Capsules present in August. (18 specimens, 2 fruiting.)
COUNTIES: Adams, Berks, Delaware, Northampton, York. (5 counties). Published, not seen: Chester, James PC; Delaware, James PC; McKean, Burnett PC.

Plagiothecium elegans (Hook.) Sull. Rare. Northern species chiefly in northern mountainous counties. On rock surfaces.
COUNTIES: Northampton, Wolle and Weygat, James 11/28/67 (A); Sullivan, Lippincott (A). Published, not seen: Carbon, Rau PC; Delaware, Strath Haven, Krout 8/20/06 TM; McKean, Burnett PC; Philadelphia, Wissahickon PC; Pike, Rau PC.

Plagiothecium elegans (Hook.) Sull., var. **Schimperi** (Jur. & Milde) Limpr. Rare.
More robust than the species. Hemlock ravine at spring outlet on soil. Elevation 950 feet.
COUNTY: Franklin, St. Thomas 5913.

Plagiothecium geophilum (Aust.) Grout. Not common. Widespread.

SUBSTRATE: Rocks and soil.
HABITAT: Deciduous woods and meadow lined with willows.
COUNTIES: Delaware, North Springfield 5950; Philadelphia, Schuylkill, James 9/63 (A) and Musci Bor. Amer. Ed. 2, Sull. & Lesq. 437 (A); Wayne, Aldenville, 3851. (3 counties). Published, not seen: Cambria, Cresson, Porter PC; Lancaster, Tees 640 TM; Lehigh, Rau PC.

Plagiothecium laetum Bry. Eur. Rare. Mountainous area.

COUNTIES: Cambria, Allegheny Mountains, James 6158 (A) and Ebensburg, James 11/58 (A).

Plagiothecium micans (Sw.) Paris. Rare. More common south of Pennsylvania.

SUBSTRATE: Soil and decaying logs.
HABITAT: Woodlands. Banks of streams and bases of trees.
COUNTIES: Delaware, Strath Haven, Krout 6/14/10; Lehigh, Shimersville, Schaeffer B53 (A); Northampton, Riverton, Schaeffer 8/11/47; Philadelphia, Morris Arboretum 6026. (4 counties). Published, not seen: Center, Bear Meadow, Porter PC.

Plagiothecium Muellerianum Schimp. Rare. Northern species. On moist soil and rocks in cool ravines, especially in crevices of rocks.

COUNTIES: Lancaster, Martic Forge, Porter 5/62 (A). Published, not seen: Bucks, Brownsburg, Tees 345 TM; Carbon. Rau PC; Philadelphia, Wissahickon, James PC.

Plagiothecium pulchellum (Hedw.) Bry. Eur., var. **nitidulum** (Wahlenb.) Husnot. Rare.
COUNTIES: Elk, Benezette, McMinn 10/68 (A). Published, not seen: Bucks, Narrowsville, James PC.

Plagiothecium Roeseanum (Hampe.) Bry. Eur. Not common. Soil in hemlock ravines. With *Pohlia nutans*.

COUNTIES: Adams, Arendtsville 5821; Philadelphia, Wissahickon, James 10/62 (A) and Pennypack, James (A). Published, not seen: Delaware, Radnor, James PC; Lancaster, Marietta, Porter PC; McKean, Burnett PC; Monroe, Cresco, James PC; Northampton, Bethlehem, Rau PC and Easton, Porter PC.

Plagiothecium striatellum (Brid.) Lindb. Not common. Wet shaded places on rocks and soil.

COUNTIES: Lehigh, Rau (A); McKean, Marilla Brook, Burnett 3147 (A); Monroe, Buck Hill Falls, Niering; Philadelphia, Wissahickon, James 6/66 (A); Sullivan, Lippincott 6/12/95 (A). (5 counties). Published, not seen: Cambria, Ebensburg, James PC; Carbon, Rau PC; Chester, Chester Valley, James PC; Delaware, Springfield, Krout 10/5/08 TM; Monroe, Garber PC; Pike, Rau PC.

Plagiothecium sylvaticum (Brid.) Bry. Eur. Not common. Northern species. On wet rocks, soil and humus in cool, shaded places.

COUNTIES: Berks, Blanda, Wilkens 6/24/27 (A) and Carsonia, Wilkens 3/4/27 (A); Delaware, Radnor, James 6/55 (A); McKean, Toad Hollow, Burnett 1329 (A); Philadelphia, Wissahickon, James 10/56 (A); York, opposite Marietta, Porter 7/11/57 (A). (5 counties). Published, not seen: Bucks, Holland, Tees 113 TM; Carbon, Rau PC; Chester, Chester Valley, James PC; Franklin, Mercersburg, Porter PC; Lehigh, Rau PC; Northampton, Green PC; Pike, Rau PC.

Plagiothecium turfaceum (Lindb.) Lindb. Rare. On decaying wood and humus. A northern species.

COUNTIES: Berks, Bernharts 5841; Cambria, Allegheny Mountains, James 6/59 (A); Monroe, Tobyhanna, Tees 176 (A). (3 counties). Published, not seen: McKean, Burnett PC; Pike, Rau PC.

VIII. HYPNACEAE

A. Stem-leaves secund, often falcate (*Heterophyllium may be found here*) . . B.
A. Stem-leaves not falcate, rarely secund . . . . . F.
B. Alar-cells enlarged, usually hyaline . . . . . C.
B. Alar-cells not enlarged, frequently small and quadrate . . . . . E.
C. Epidermis of capsule not collenchymatous . . . . . D.
C. Epidermis of capsule collenchymatous . . . . . 4. *Sematophyllum.*
D. Operculum long-rostrate . . . . . 2. *Brotherella.*
D. Operculum conical to short-rostrate . . . . . 1. *Hypnum.*
E. Capsule erect, symmetric; segments of the inner peristome at least partially adherent to outer peristome teeth; cilia absent or rudimentary . . . 7. *Pylaisia.*
E. Capsules erect or more usually asymmetric; segments free; cilia usually well developed . . . . . 1. *Hypnum.*
F. Capsules erect, symmetric; peristome without cilia . . . . 8. *Platygyrium.*
F. Capsules inclined to horizontal, usually curved; peristome with cilia . . G.
G. Alar-cells enlarged and hyaline . . . . . 3. *Heterophyllium.*
G. Alar-cells not enlarged, often small and quadrate . . . . . H.
H. Gametophyte very minute; leaves 0.8 mm. or less in length 6. *Amblystegiella.*
H. Gametophyte of medium size; leaves about 1 mm. in length 5. *Homomallium.*

1. HYPNUM Hedw.

A. Alar cells conspicuously enlarged, hyaline and thin-walled . . . . . B.
A. Alar cells not conspicuously enlarged, often small . . . . . C.
B. Region of enlarged alar-cells abruptly delimited from remaining leaf-cells *Patientiae.*
B. Region of enlarged alar-cells gradually intergrading with remaining leaf-cells . . . . . *pratense.*
C. Leaf papillose beneath with sharply projecting cell-ends . . . . . *molluscum.*
C. Leaf not papillose . . . . . D.
D. Gametophyte yellowish-green; beautifully plumose-pinnate; leaf plicate, apex curved toward the next lower branch . . . . . *crista-castrensis.*
D. Gametophyte seldom yellowish-green; pinnately or irregularly branched; leaf seldom plicate, apex curved toward the substrate . . . . . E.
E. Capsule nearly erect and symmetric . . . . . F.
E. Capsule curved, asymmetric, inclined or horizontal . . . . . G.
F. Gametophyte relatively large; capsule 3–4 mm. long . . . . . *imponens.*
F. Gametophyte relatively small; capsule less than 2 mm. long . . . *pallescens.*
G. Quadrate alar cells very numerous . . . . . H.
G. Quadrate alar cells few or none . . . . . I.
H. Leaf usually entire, with a few slightly enlarged alar cells . . *cupressiforme.*
H. Leaf serrate, with no enlarged alar-cells . . . . . *reptile.*
I. Capsule when dry longitudinally plicate . . . . . *curvifolium.*
I. Capsule when dry smooth or slightly wrinkled . . . . . *fertile.*

Hypnum crista-castrensis Hedw. Not common. Confined to the "cool" mountainous area.

SUBSTRATE: Soil and decaying logs.

HABITAT: Eastern hemlock formation. In swampy bottoms and along streams. Elevation 1000 to 1700 feet.
ASSOCIATES: With *Hylocomium* spp., *Hypnum* spp., and *Thuidium delicatulum*.
COUNTIES: Blair, Bradford, Elk, Lehigh, McKean, Monroe, Northampton, Pike, Potter, Tioga. (10 counties). Published, not seen: Cambria, Cresson, Porter PC; Carbon, Rau PC; Chester, New Garden, Michener PC; Clinton, Renovo J; Delaware, Smith PC; Lancaster, Martic Forge, Porter PC; Philadelphia, Wissahickon, James PC; Somerset, Allegheny Mountains, Patterson J.

Hypnum cupressiforme Hedw. Not common.

SUBSTRATE: Bark of trees.
HABITAT: Forests. Bases of trees.
COUNTIES: Chester, Coventry, James 12/20/50 (A) and Falls of French Creek, Kaiser 3/21/11 (var. filiforme.); McKean, Rutherford Rocks, Burnett 1944 (var. filiforme.) (A); Philadelphia, Falls of the Pennypack, Krout 8/29/08, W. bank of Schuylkill, James (A), Wissahickon, James 10/56 (A) and James 10/58 (A). (3 counties). Published, not seen: Cambria, Ebensburg, James PC; Lancaster, Mount Hope, Small PC and Beartown, Eby 4/00 SMS.

Hypnum curvifolium Hedw. Fairly common. "Cool" mountainous area.

SUBSTRATE: Soil, decaying logs and humus covered rocks.
HABITAT: All forest types and grassy area at edge of woods. Stream banks, roadsides, wooded slopes and bridge masonry. Elevation 220 to 1600 feet.
ASSOCIATES: *Atrichum* spp. (12 specimens.)
COUNTIES: Cumberland, Lancaster, McKean, Monroe, Northampton, Philadelphia, Potter, York. (8 counties). Published, not seen: Bucks, Rau PC; Cambria, Ebensburg, James PC; Carbon, Rau PC; Chester, Chester Valley, James PC; Delaware, James PC and West Bradford Township, Krout 9/19/10 TM; Pike, Rau PC; Somerset, Ursina J.

Hypnum fertile Sendt. Rare. On decaying wood. "Cool" area.

COUNTIES: Cambria, Allegheny Mountains, James 6/68 (A) and Chestnut Creek, James 6/58 (A); McKean, Bennett Brook, Burnett 8/8/97. Published, not seen: Chester, Elverson, Krout TM; Pike, Rau PC.

Hypnum imponens Hedw. Commonest species in the state. Widespread.

SUBSTRATE: Decaying logs, soil and humus covered rock surfaces. pH4 to 5.
HABITAT: All forest types. Wooded slopes, stream banks, ditches and culverts and shaded road banks. Elevation 150 to 2100 feet.
ASSOCIATES: With species of *Dicranum*, *Polytrichum*, *Hypnum*, *Mnium*, *Eurhynchium*, *Heterophyllium Haldanianum*, *Leucobryum glaucum* and *Cladonia*.
REPRODUCTION: Capsules mature in autumn. Closed in September, but open in November and December. (57 specimens, 13 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Carbon, Center, Chester, Clinton, Columbia, Cumberland, Dauphin, Delaware, Elk, Lancaster, Lehigh, McKean, Mercer, Monroe, Northampton, Philadelphia, Potter, Somerset, Sullivan Tioga, Warren, York. (26 counties). Published, not seen: Cambria, Cresson, Porter PC; Franklin, Porter PC; Montgomery, Fraser's Bog, Wismer TM; Pike, Rau PC.

Hypnum molluscum Hedw. Fairly common. Widespread.

SUBSTRATE: Soil and exposed roots.
HABITAT: Hardwoods. Wooded hillside, shaded roadbanks and serpentine barrens. Elevation 100 to 1450 feet.
COUNTIES: Lancaster, McKean, Montgomery, Northampton, Philadelphia, Warren. (6 counties). Published, not seen: Blair, Garber PC; Cambria, Cresson, Porter PC; Chester, New Garden, Michener; Delaware, Smith PC; Elk, McMinn PC; Lehigh, Rau PC; McKean, Burnett PC; Monroe, James PC.

Hypnum pallescens (Hedw.) Bry. Eur. Very rare. A northern species. On soil.
COUNTIES: Monroe, Pocono Mountain, Porter 8/59 (A). Published, not seen: Cambria, Cresson, Porter; Pike, Rau PC.

Hypnum Patientiae Lindb. Fairly common. "Cool" mountainous area.
SUBSTRATE: Soil, humus and rotting wood.
HABITAT: Principally in the hardwood forest. Hillsides, shaded banks of brooks, old fields and ravines. Elevation 80 to 1600 feet. (14 specimens.)
COUNTIES: Bucks, Columbia, Delaware, McKean, Montgomery, Potter, Sullivan, Tioga, Warren. (9 counties). Published, not seen: Berks, Mineral Springs Park, Wilkens 11, 13, 27 and Wernersville, Tees 271 TM; Philadelphia, Wissahickon, Kaiser TM.

Hypnum Patientiae Lindb., var. **elatum** Schimp.
COUNTIES: Bucks, Delaware.

Hypnum pratense Koch. Fairly common. Chiefly in the "cool" mountainous area.
SUBSTRATE: Soil, humus and wet rock surfaces.
HABITAT: Principally eastern hemlock forest. Hillsides, ravines, shaded banks of brooks, wet cliffs and roadsides. Elevation 600 to 1520 feet. (13 specimens.)
COUNTIES: Berks, Bradford, Cambria, Columbia, Cumberland, Lancaster, Lehigh, McKean, Monroe, Northampton, Tioga. (11 counties). Published, not seen: Chester, Downingtown, Tees 156 TM; Philadelphia, James PC.

Hypnum reptile Mx. Fairly common. Confined to the northern mountainous counties.
SUBSTRATE: Bark, rotting wood and rock surfaces.
HABITAT: Chiefly in the eastern hemlock forest. Elevation 750 to 2000 feet.
REPRODUCTION: Capsules closed in July. Open and shedding spores, August to September. (19 specimens, 10 fruiting.)
COUNTIES: Berks, Bradford, McKean, Monroe, Pike, Schuylkill, Sullivan, Susquehanna. (8 counties). Published, not seen: Delaware, Smith TM; Lancaster, Muhlenberg PC.

2. BROTHERELLA Loeske.

A. Gametophyte complanate-foliate; capsule asymmetric and inclined; cilia of peristome well developed . . . . . B.
A. Gametophyte little complanate; capsule erect and symmetric; cilia none or rudimentary . . . . . *tenuirostris*.
B. Gametophyte glossy, yellowish-green; operculum one-half as long as the rest of the capsule . . . . . *recurvans*.
B. Gametophyte not very glossy, seldom yellowish; operculum nearly as long as the rest of the capsule . . . . . *delicatula*.

Brotherella delicatula (James) Fleisch. Very rare.
Published, not seen: McKean, Bradford, Burnett PC

Brotherella recurvans (Mx.) Fleisch. Common. "Cool" mountainous area.
SUBSTRATE: Soil, rotting logs and humus covered rocks.
HABITAT: Eastern hemlock formation. Stream banks, wooded hillsides, and swampy woods. Elevation 1400 to 1940 feet.
REPRODUCTION: Capsules mature but closed in September. Open in November. (18 specimens, 8 fruiting.)
COUNTIES: Berks, Bradford, Center, Clinton, Elk, Lehigh, McKean, Monroe, Northampton, Pike, Potter, Sullivan, Tioga. (13 counties). Published, not seen: Carbon, Rau PC; Chester, James PC; Delaware, James PC; Lancaster, Mount Hope, Small PC and Chickies, Porter PC; Philadelphia, James PC; Somerset, Keystone J.

Brotherella tenuirostris (Schimp.) Broth. Rare. "Cool" mountainous area.

SUBSTRATE: Bases of trees, rotting wood and humus.
HABITAT: Wooded stream banks.
COUNTIES: Berks, Mineral Springs Park, Wilkens 11/13/22 (A); Carbon, Stony Creek, Wolle 8/74 and Onoko Glen, Wolle and Rau 7/73 (A); Chester, N. of Daylesford 4529; Northampton, Bethlehem, Rau (A). (4 counties). Published, not seen: Monroe, Delaware Water Gap, Austin PC.

3. HETEROPHYLLIUM (Schimp.) Kindb.

Heterophyllium Haldanianum (Grev.) Kindb. Common. Widespread.

SUBSTRATE: Soil, rotting wood, humus covered rocks and exposed roots. pH4 to 6.
HABITAT: All forest types, old fields and thickets. Stream banks, hillsides, wood roads and swamps. Elevation 100 to 1700 feet.
ASSOCIATES: *Mnium cuspidatum* and *Tetraphis pellucida.*
REPRODUCTION: Capsules closed in September. Open and shedding spores in December. (40 specimens, 25 fruiting.)
COUNTIES: Adams, Bradford, Berks, Bucks, Clinton, Columbia, Cumberland, Delaware, Lancaster, Lehigh, McKean, Monroe, Montgomery, Philadelphia, Pike, Potter, Schuylkill, Susquehanna, Tioga, Warren, York. (21 counties.) Published, not seen: Cambria, Cresson, Porter PC and Ebensburg, James PC; Chester, Chester Valley, James PC; Elk, McMinn PC; Northampton, Bethlehem, Rau PC.

4. SEMATOPHYLLUM Mitt.

A. Gametophyte growing on trees or recently fallen logs; capsule nearly erect and symmetric . . . . . *adnatum*
A. Gametophyte growing on rocks; capsule curved and asymmetric . . . . . B.
B. Leaf 1.5 mm. or less in length . . . . . *carolinianum.*
B. Leaf 2 mm. or more in length . . . . . *marylandicum.*

Sematophyllum adnatum (Mx.) E. G. Britton. Rare. On bark of living trees.

COUNTIES: Chester, Daylesford, Stewart 3/30/46. Published, not seen: Delaware, Paper Mill, Krout 9/6/99 TM; Monroe, Buck Hill Falls, Britton PC; Philadelphia, Wissahickon, Krout 8/5/08 TM.

Sematophyllum carolinianum (C. Mull.) E. G. Britton. Uncommon.

SUBSTRATE: Rocks and soil.
COUNTIES: Lehigh, Rau (A); Northampton, Bushkill Gap, Porter 10/69 (A); Weygat, Porter 8/14/76 (A) and Easton, Garber (A); Philadelphia, Wissahickon, James 10/68 (var. *admixtum*) (A); Sullivan, Eaglesmere, Githens 222; York, Long Level, 1996. Published, not seen: Carbon, Rau PC.

Sematophyllum marylandicum (C. Mull.) E. G. Britton. Very rare. On stones and ledges in and near cold brooks.

COUNTIES: Carbon, Onoko Glen, Wolle 7/73.

5. HOMOMALLIUM (Schimp.) Loeske.

Homomallium adnatum (Hedw.) Broth. Common. Widespread.

SUBSTRATE: On bark and rock surfaces.
HABITAT: All forest types. On roots of willows and bark of trees, up to two feet above the ground, along stream banks. Elevation 100 to 1300 feet.
ASSOCIATES: *Mnium cuspidatum.*
Type locality: Lancaster, Pennsylvania.
COUNTIES: Berks, Bucks, Franklin, Juniata, Lancaster, Lehigh, Northampton, Philadelphia, Wayne, York. (10 counties). Published, not seen: Monroe, Bushkill Falls, Britton PC.

6. AMBLYSTEGIELLA Loeske.

A. Plants growing on the base of deciduous trees, leaves reaching 0.6 mm. or more in length . . . . . *subtilis.*

A. Plants growing on stones, especially limestone; leaves usually less than 0.5 mm. in length . . . . . *confervoides.*

Amblystegiella confervoides (Brid.) Loeske. Rare. Soil on boulders. Beech-maple woods along stream banks.

COUNTIES: Tioga, Mansfield 4060. Published, not seen: Huntingdon, Pennsylvania Furnace J; Lancaster, Porter PC; Northampton, Easton, Porter PC and Bethlehem, Rau PC.

Amblystegiella subtilis (Hedw.) Loeske. Rare. On trees and logs along stream banks.

COUNTIES: Delaware, Lima, Krout 8/9/04; Lehigh, Fogelsville, Schaeffer 11/28/47. Published, not seen: Berks, Wyomissing, Wilkens 2/23/30 TM; Chester, Cornog, Kaiser 11/18/11 SMS; Lancaster, Muhlenberg TM and Bartsville, Jackson 12/16 SMS.

7. PYLAISIA Bry. Eur.

A. Segments of endostome free from the teeth . . . . . *polyantha.*

A. Segments of endostome wholly or partially adherent to the teeth . . . . . B.

B. Segments partially adherent; spores 18–24 microns . . . . . *Selwynii.*

B. Segments wholly adherent; spores 24–70 microns . . . . . *intricata.*

Pylaisia intricata (Hedw.) Bry. Eur. Not common. Eastern Pennsylvania.

SUBSTRATE: Bark of trees and old logs.
HABITAT: Moist woods.
Type locality: Lancaster, Pennsylvania.
COUNTIES: Lancaster, New Texas, Carter 12/93 (A); Lehigh, Rau (A); Northampton, Shimersville, Schaeffer B52, Weygat, James 1008 (A) and Easton, Porter 1868 (A); Philadelphia, Wissahickon, James 4/57 (A) and Bartram's Garden, James 5/51 (A); Pike, Elbow Swamp, Rau 1873 (A). (5 counties). Published, not seen: Carbon, Rau PC, Chester, Darlington, TM; Delaware, Glenolden, Krout 12/21/07 TM; McKean, Burnett PC.

Pylaisia polyantha Bry. Eur. Rare. No specimens seen.

Published records: McKean, Burnett PC.

Pylaisia Selwynii Kindb. Rare. Bases of trees.

COUNTIES: Lancaster, New Texas, Carter 2/94 (A) and Conewago, Small 1/1/92 (A). Published, not seen: Chester, Coventry, James PC; Clearfield, Phillipsburg, James PC; Delaware, James PC; Elk, McMinn PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC and Easton, Porter PC; Philadelphia, James PC.

8. PLATYGYRIUM Bry. Eur

Platygyrium repens (Brid.) Bry. Eur. Common. Widespread.

SUBSTRATE: Bark and rotting logs.
HABITAT: All forest types. Ravines, wooded slopes and mountain tops. Logs, stumps and up to 5 feet on living trees. Elevation 100 to 2567 feet.
ASSOCIATES: *Heterophyllium Haldanianum*, *Dicranella heteromalla* and various lichens.
REPRODUCTION: Capsules mature in September and remain closed in October. (22 specimens, 5 fruiting.)

COUNTIES: Bedford, Berks, Bucks, Chester, Columbia, Delaware, Lancaster, Lycoming, Monroe, Montour, Philadelphia, Somerset, Susquehanna, York. (14 counties). Published, not seen: McKean, Bradford, Burnett PC; Northampton, Rau PC.

IX. HYLOCOMIACEAE

A. Paraphyllia lacking or rare . . . . . B.
A. Paraphyllia abundant . . . . . 3. *Hylocomium.*
B. Leaf secund and rugose . . . . . 1. *Rhytidium.*
B. Leaf spreading to squarrose, often plicate but not rugose 2. *Rhytidiadelphus.*

1. RHYTIDIUM (Sull.) Kindb.

Rhytidium rugosum (Hedw.) Kindb. Rare. Northern species, confined to "cool" area.

SUBSTRATE: Soil and rock surface in high dry cliffs.
COUNTIES: Bradford, Towanda, Barbour 6; Franklin, Mercersburg, Porter (A); Lehigh, Rau (A); Northampton, Easton, Wolle and Porter 1868 (A). Published, not seen: Bucks, Nockamixon, Small PC; Huntingdon, Porter PC; Lancaster, Porter PC.

2. RHYTIDIADELPHUS (Lindb.) Warnst.

A. Leaf smooth beneath, slenderly acuminate . . . . . *squarrose.*
A. Leaf spinose-papillose beneath, shortly acuminate . . . . . *triquetrus.*

Rhytidiadelphus squarrose (Hedw.) Warnst. Rare. "Cool" mountainous area. On logs, soil and rocks in cool shady places.
COUNTIES: Northampton, Rau (A); Pike, Wolle 8/72. Published, not seen: Cambria, Cresson, Lesquereux PC.

Rhytidiadelphus triquetrus (Hedw.) Warnst. Not common. Northern species confined to eastern hemlock formation. On moist soil in shaded spots.

COUNTIES: Bucks, Lancaster, Lehigh, Lycoming, McKean, Monroe, Montgomery, Northampton, Sullivan. (9 counties). Published, not seen: Cambria, Porter PC; Carbon, Rau PC; Chester, James PC; Delaware, James PC; Elk, McMinn PC; Luzerne, Small PC; Philadelphia, Fairmount Park, James PC; Pike, Rau PC.

3. HYLOCOMIUM Bry. Eur.

A. Stems closely and regularly bi-tri-pinnate . . . . . *splendens.*
A. Stems branching irregularly, or irregularly pinnate . . . . . B.
B. Stem leaves decurrent and coarsely toothed at base . . . . . *umbratum.*
B. Stem leaves rounded-cordate at base and finely toothed . . . . *brevirostre.*

Hylocomium brevirostre (Beauv.) Bry. Eur. Not common. A northern species found in the eastern hemlock formation, principally in the "cool" area of the state.

SUBSTRATE: On decaying logs and humus covered rock surfaces.
HABITAT: Eastern hemlock forest. Swampy areas. Elevation 150 to 1600 feet.
ASSOCIATES: *Hypnum crista-castrensis* and *Hylocomium splendens.* (10 specimens.)
COUNTIES: Elk, Lehigh, McKean, Monroe, Philadelphia, Pike, Sullivan. (7 counties). Published, not seen: Blair, Porter PC; Cambria, James PC; Delaware, Smith TM; Lancaster, Martic Forge, Porter PC and Tucquan Creek, Eby 5/00 SMS; Northampton, Rau PC.

Hylocomium splendens (Hedw.) Bry. Eur. Fairly common. Northern species occurring in eastern hemlock forest, chiefly the "cool" region of the state.

SUBSTRATE: Decaying logs and hummocks of humus in wet swampy areas.
HABITAT: Eastern hemlock forest. Elevation 300 to 1700 feet.

ASSOCIATES: *Hypnum crista-castrensis, Hylocomium brevirostre, Thuidium delicatulum, Sphagnum* spp. (8 specimens.)
COUNTIES: Bucks, Clinton, McKean, Monroe, Northampton, Potter, Sullivan. (7 counties). Published, not seen: Blair, Porter PC; Carbon, Rau PC; Elk, McMinn PC; Lancaster, Martic Forge, Porter PC and Tucquan Creek, Eby 6/92 SMS; Luzerne, Pond Hill, Small PC; Philadelphia, Wissahickon, James PC; Pike, Rau PC.

Hylocomium umbratum (Hedw.) Bry. Eur. Rare. A northern species, same range in Pennsylvania as the two preceding species. Old logs and humus in wet shaded areas.
COUNTIES: McKean, Marilla Brook, Burnett 4 21 '97 (A); Philadelphia, Upper Wissahickon, Krout 8/5/08.

X. BRYACEAE

A. Leaf linear-lanceolate . . . . . 1. *Leptobryum.*
A. Leaf ovate to lanceolate . . . . . B.
B. Leaf-cells at least 4 times as long as wide . . . . . 2. *Pohlia.*
B. Leaf-cells less than 4 times as long as wide . . . . . C.
C. Leaves in compact rosettes . . . . . 4. *Rhodobryum.*
C. Leaves not in compact rosettes . . . . . 3. *Bryum.*

1. LEPTOBRYUM (Bry. Eur.) Schimp.

Leptobryum pyriforme (Hedw.) Schimp. Not common. On soil. Widespread, of cosmopolitan distribution.
COUNTIES: Cambria, McKean, Monroe, Northampton, Philadelphia. (5 counties). Published, not seen: Chester, New Garden, Michener PC; Lancaster, Muhlenberg PC and Porter PC.

2. POHLIA Hedw. (Webera Hedw.)

A. Gametophyte with a distinct metallic lustre . . . . . *cruda.*
A. Gametophyte without such a lustre . . . . . B.
B. Gametophyte of a whitish-green color, with somewhat the appearance of the genus, *Philonotis* . . . . . *Wahlenbergii.*
B. Gametophyte ordinary green color . . . . . C.
C. Capsule about twice as long as wide . . . . . *nutans.*
C. Capsule often as wide as long . . . . . *pulchella.*

Pohlia cruda (Hedw.) Lindb. Rare. A northern species. On moist rocks and soil, in shaded situations.
COUNTIES: Lancaster, Conestoga, Porter 5/5/64 (A); Northampton, Easton, Porter 4/28/62 (A); Bushkill Gap, Wolle 6/74 and Bethlehem, Rau (A). Published, not seen: Bucks, Narrowsville, Porter PC; Lehigh, Rau PC.

Pohlia nutans (Hedw.) Lindb. Very common. Widespread.
SUBSTRATE: Soil, rocks and humus, rotting wood and cinders. pH4 to 6.
HABITAT: All forest types. Ravines, road banks, shale bluffs, mountain tops, bases of trees, crevices in rocks, and city streets. In sun and shade. Elevation 100 to 2200 feet.
ASSOCIATES: Usually with *Dicranella heteromalla, Ceratodon purpureus* and species of *Cladonia*. Also with many other species of mosses.
REPRODUCTION: Archegonia and antheridia mature in April. Young sporophytes appear in November and December. Capsules are mature and shedding spores by July and August. (80 specimens examined, 46 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Carbon, Chester, Clinton, Columbia, Delaware, Franklin, Fulton, Lackawanna, Lancaster, Lehigh, Lycoming, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder,

Somerset, Sullivan, Susquehanna, Tioga, Wayne, York. (30 counties). Published, not seen: Cambria, Cresson J; Center, Scotia and Tussey's Mountain, J; McKean, Burnett PC; Montour, Montour Mountain J.

Pohlia pulchella (Hedw.) Lindb. Not common. Widespread.

SUBSTRATE: Soil.
HABITAT: Wooded roadsides, clay banks and stream banks. Elevation 100 to 800 feet.
REPRODUCTION: Capsules mature in May and June. (10 specimens, 6 fruiting.)
COUNTIES: Adams, Carbon, Delaware, Huntingdon, Lehigh, Monroe, Northampton, Philadelphia. (8 counties). Published, not seen: Bucks, James PC; Chester, James PC; Lancaster, Muhlenberg PC and Bartsville, Jackson 11/16 SMS.

Pohlia Wahlenbergii (Web. & Mohr.) Andrews. Fairly common. Widespread.

SUBSTRATE: Soil.
HABITAT: Woodlands. Stream banks, edge of ponds, road banks and ditches and wet cliffs. (20 specimens.)
COUNTIES: Bucks, Chester, Columbia, Dauphin, Elk, Lancaster, Lehigh, McKean Monroe, Montgomery, Montour, Northampton, Philadelphia. (13 counties). Published, not seen: Delaware, Smith TM.

3. BRYUM (L.) Hedw

A. Gametophyte usually whitish or silvery . . . . . *argenteum.*
A. Gametophyte some shade of green, brown or red . . . . . B.
B. Costa long excurrent . . . . . C.
B. Costa short excurrent or percurrent . . . . . D.
C. Leaf-cells usually less than 1½ times as long as wide; leaf-border usually inconspicuous . . . . . *capillare.*
C. Leaf-cells usually at least 2 times as long as wide; leaf-border usually conspicuous proximally . . . . . *caespiticium.*
D. Leaf-cells usually less than 1½ times as long as wide; border usually conspicuous . . . . . *capillare.*
D. Leaf-cells usually twice as long as wide, border various . . . . . E.
E. Capsule purple-red at maturity, rounded at base . . . . . *bicolor.*
E. Capsule not usually brilliant at maturity, tapering toward base . . . . . F.
F. Gametophyte dioicous . . . . . *pseudotriquetrum.*
F. Gametophyte synoicous . . . . . *cuspidatum.*

Bryum argenteum (L.) Hedw. Common. Widespread.

SUBSTRATE: Soil, slag, mortar of walls and rock. (Conglomerate and limestone.) pH8.
HABITAT: Open woods and exposed situations. Stone work, boulders roadsides and sidewalks. Elevation 100 to 640 feet.
REPRODUCTION: Capsules closed and immature in October and November. Opening from December to February. (38 specimens, 11 fruiting.)
COUNTIES: Adams, Berks, Bucks, Delaware, Franklin, Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Philadelphia. (13 counties). Published, not seen: Chester, Darlington TM; Huntingdon, Union Furnace J.

Bryum bicolor Dicks. Rare. Widespread.

COUNTIES: Beaver, James (A); Northampton, Easton, James (A); Philadelphia, James (A); York, James (A).

Bryum caespiticium (L.) Hedw. Common. Widespread.

SUBSTRATE: Soil, ashes, cinders, slag and mortar. pH7 to 8.
HABITAT: Edge of woods, meadows and exposed situations. Base of cliffs, river shores, railroad embankments, dumps and walls. Elevation 100 to 1300 feet.

REPRODUCTION: Antheridia mature in April. Capsules mature and open in May and June. (25 specimens, 14 fruiting.)
COUNTIES: Adams, Berks, Bucks, Cambria, Chester, Delaware, Franklin, Lancaster, Lehigh, McKean, Monroe, Northampton, Philadelphia, Schuylkill, Wayne. (15 counties). Published, not seen: Center, Scotia J; Clinton, Lock Haven J; Huntingdon, Birmingham J; Montgomery, Melrose, Long 551 TM.

Bryum capillare (L.) Hedw. Fairly common. Widespread.
SUBSTRATE: Rocks and humus accumulation.
HABITAT: All forest types. On boulders and in ravines. Elevation 100 to 1300 feet.
COUNTIES: Bucks, Cambria, Chester, Dauphin, Lycoming, Monroe, Philadelphia. (7 counties). Published, not seen: Carbon, Mauch Chunk, James PC; Delaware, Smith TM; McKean, Burnett PC; Northampton, Porter PC; York, Wrightsville, Small PC.

Bryum cuspidatum (Bry. Eur.) Schimp. Fairly common. Widespread.
SUBSTRATE: Soil, cinders, alluvium and rock surface (limestone). pH7.
HABITAT: Hardwood forests. Shaded rocks, bridge masonry and railroad embankments. Elevation 150 to 1100 feet.
ASSOCIATES: *Funaria hygrometrica.*
REPRODUCTION: Anthericia and archegonia present in May. Capsules mature in June and July. (13 specimens, 9 fruiting.)
COUNTIES: Bedford, Bucks, Center, Clearfield, Franklin, Lancaster, Lycoming, Monroe, Northampton, Philadelphia, Somerset. (11 counties). Published, not seen: Cambria, James PC; Delaware, Glenolden, Krout 5 25 11 SMS; McKean, Bradford, Burnett J.

Bryum pseudotriquetrum (Hedw.) Schwaegr. Fairly common. Widespread.
SUBSTRATE: Wet soil and humus covered rocks.
HABITAT: All forest types. Stream banks, ravines, wet cliffs, and roadside ditches. Elevation 200 to 1520 feet.
REPRODUCTION: Antheridia and archegonia mature in early May. Capsules open and shedding spores from June to August. (21 specimens, 6 fruiting.)
COUNTIES: Bradford, Bucks, Cambria, Columbia, Delaware, Elk, Franklin, Lancaster, Lehigh, McKean, Monroe, Northampton, Venango, York. (14 counties). Published, not seen: Center, Scotia J.

4. RHODOBRYUM (Schimp.) Hampe

Rhodobryum roseum (Bry. Eur.) Limpr. Fairly common. All physiographic provinces in Pennsylvania.
SUBSTRATE: Soil, and rock surface. Preference for conglomerate and limestone. pH7–8.
HABITAT: Mixed hardwoods and hemlock-hardwoods along stream banks, on pond shores and in swampy areas. Elevation 50 to 2000 feet.
ASSOCIATES: Frequently overgrown by *Mnium affine* and *M. punctatum.*
REPRODUCTION: Archegonia open in October collections. Blooming period reported as September by Towle (1908). Sporophytes almost mature in September, but do not open and shed spores until March or April. (42 specimens examined, 8 fruiting.)
COUNTIES: Berks, Blair, Bradford, Bucks, Center, Chester, Clinton, Delaware, Franklin, Huntingdon, Lancaster, Lehigh, Luzerne, McKean, Monroe, Northampton, Philadelphia, Potter, Schuylkill, Sullivan. (20 counties). Published, not seen: Pike, Garber PC.

XI. MNIACEAE

MNIUM Hedw.

A. Leaves not bordered . . . . . B.
A. Leaves bordered . . . . . C.
B. Large plants, leaves entire or only slightly serrate; leaf cells twice as long as broad . . . . . *cinclidioides.*
B. Small plants, leaves usually serrate; leaf cells isodiametric . . . . . *stellare.*
C. Leaves entire . . . . . D.
C. Leaves serrate, single teeth . . . . . E.
C. Leaves serrate, teeth in pairs . . . . . I.
D. Small plants, leaves usually costate to apex . . . . . *punctatum.*
D. Large plants, leaf margins thickened, of 2–4 layers, rarely fruiting *punctatum* var. *elatum.*
E. Leaves serrate to base or nearly so, capsules clustered . . . . . F.
E. Leaves serrate in the upper ½ or ⅔ only . . . . . H.
F. Teeth of margins very short, operculum strongly beaked . . . *longirostrum.*
F. Teeth of margins generally 2–5 cells; operculum mammillate or apiculate G.
G. Dioiceous; many marginal teeth of more than 2 cells . . . . . *affine.*
G. Synoiceous; marginal teeth shorter, few of more than 2 cells . . . . *medium.*
H. Capsules clustered, leaves little shriveled in drying, not stoloniferous *Drummondii.*
H. Capsules single, leaves strongly shriveled when dry, stoloniferous *cuspidatum.*
I. Leaves long and narrow, costa evanishing below apex . . . . . *hornum.*
I. Leaves wider, costa reaching apex in upper leaves at least . . . . . J.
J. Costa toothed dorsally, cells not collenchymatous . . . . *orthorhynchum.*
J. Costa not toothed dorsally, cells rounded and collenchymatous . . *serratum.*

Mnium affine Bland. Abundant. In all the physiographic provinces. Varieties *rugicum* and *ciliata* are included under the species. Examination of many specimens clearly show both types of leaf variations on the same plant.

SUBSTRATE: Clay and sandy soil, humus accumulated on rock surfaces and rotten wood. pH4 to 7. (One record of pH8.)

HABITAT: All forest types occurring within the state. More frequent in stream bottoms and the moister shadier habitats. Occasionally in drier situations on slopes and bluffs. From 100 to 2200 feet.

ASSOCIATES: Most frequently with species of *Thuidium*, *Hypnum*, and other species of *Mnium*. Less often with *Climacium* and *Dicranum*.

REPRODUCTION: Mature archegonia were found in plants collected in August. An October collection contained developing archegonia which were twice their mature length. In other October and November specimens the archegonia were open and many had become brown and shriveled. Mature antheridia also were found in August. By late September and October they were open and empty. The capsules mature by April and are shedding spores. Empty capsules remain attached to the plants from May to July. (136 specimens examined, 11 fruiting.)

COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Cambria, Carbon, Center, Chester, Clearfield, Columbia, Cumberland, Delaware, Elk, Franklin, Fulton, Juniata, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, York. (44 counties.)

Mnium cinclidioides (Blyth.) Huebener. Rare. Mountains of the northern part of the state. A northern species that occurs in glaciated areas.

SUBSTRATE: Decaying logs and humus.
HABITAT: Swampy woods and sphagnum bogs. Elevation 1600 feet.
ASSOCIATES: With *Mnium hornum*.
REPRODUCTION: Capsules green and closed but well formed on April 30, 1945, in Monroe county collection. (6 specimens.)
COUNTIES: Carbon, Hazelton, Wolle; Luzerne, Glen Summit Spring, Ruth (A); McKean, West Branch Swamp (A & NY); Monroe, Pocono Lake Preserve, Harper 1642 (A & P). (4 counties.)

Mnium cuspidatum Hedw. Abundant. In all physiographic provinces.

SUBSTRATE: Soil, rotting wood and humus on rock surfaces. pH4 to 8, most samples at 6 and 7.
HABITAT: All forest types of the state. In drier situations generally than *M. affine*, although it has been collected along stream banks and in swampy thickets. Elevation 50 to 2567 feet.
ASSOCIATES: Growing with other species of *Mnium* and species of *Hypnum*, *Atrichum* and *Plagiothecium*.
REPRODUCTION: Antheridia and archegonia present and mature in May and early June. Mature capsules are present in April and many are open and shedding spores. This continues into May, by June the capsules are empty and remain on the plants until August. Young sporophytes are sometimes visible as early as August, but the majority appear in September and October. In measuring the length of many specimens, a great variation in the rate of growth was observed. By March the setae average 2 cm. long. (205 specimens examined, 76 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Carbon, Center, Chester, Columbia, Cumberland, Dauphin, Delaware, Franklin, Huntingdon, Juniata, Lancaster, Lehigh, Luzerne, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Somerset, Sullivan, Susquehanna, Tioga, Venango, Wayne, York. (37 counties.) Published, not seen: Clearfield, DuBois, Moldenke 4113. (A specimen marked *M. spinulosum* from Luzerne County, Glen Summit Springs, Ruth 6/3/05 upon examination proves to be *M. cuspidatum*.)

Mnium Drummondii Bry. Eur. Rare. More frequent in the northern tier of states. On soil. One record for Pennsylvania. Lycoming county, McMinn, April 1869. James Herbarium (A. & C.).

Mnium hornum Hedw. Fairly common in Coastal Plain, Piedmont, Ridge and Valley Provinces. A few collections were made west of the Allegheny Mountain front along tributaries of the east flowing rivers. Dr. O. E. Jennings has collected it in 12 counties along the Allegheny Plateau from the southern boundary of the state to the northern boundary.

SUBSTRATE: Soil, humus, rotting wood and rock surfaces.
HABITAT: Prefers the dense shade and moisture of hemlock ravines and rhododendron thickets. Occasionally in dense stands of hardwoods along stream valleys and lake shores. Elevation 150 to 2100 feet.
ASSOCIATES: *Atrichum crispum*, *Mnium cinclidioides*, *M. punctatum* and *Tetraphis pellucida*.
REPRODUCTION: Mature capsules present in June and July. (35 specimens examined, 5 fruiting.)
COUNTIES: Bedford, Carbon, Center, Chester, Clinton, Dauphin, Delaware, Lancaster, Lehigh, Lycoming, McKean, Mifflin, Monroe, Northampton, Philadelphia, Pike, Schuylkill, Sullivan, Union, York. (20 counties). Published, not seen: Cambria, PC; 12 counties along Allegheny Plateau, J.

Mnium longirostrum Brid. Rare. World wide in its distribution, but better represented in southern part of North America. Moist rocks, humus and soil in the woods.

COUNTIES: Bucks, Narrowsville, Porter & James (A & C); Lancaster, Welsh Mountains and West Branch of Octoraro Creek, Small (NY); Lebanon, Mt. Gretna 2650; McKean, Corydon 4445 and Quintuple, Burnett 901a (NY); Pike, Rau 7/72 (NY); York, Emigsville, 3434. (6 counties). Published, not seen: Cambria, James, PC; Lycoming, McMinn, PC.

Mnium medium Bry. Eur. Rare. A northern species.

SUBSTRATE: Soil and leaf mold.
HABITAT: Shaded ravines and stream banks.
COUNTIES: Berks, Jacksonwald, Wilkens 232; McKean, Marilla Brook, Gates Hollow, Quintuple, Lewis Run and West Branch Swamp, Burnett (NY); Monroe, James (A & C). (3 counties.)

(*Mnium lycopodioides* (Hook.) Schwaegr. A species of northern distribution. Reported from Pennsylvania but all specimens seen are referable to *M. orthorhynchum*.)

Mnium orthorhynchum Brid. Rare. Probably overlooked. Confined chiefly to mountainous districts.

SUBSTRATE: Rocks and soil. Shows preference for calcareous substrate.
HABITAT: In hemlock and mixed hemlock-hardwood forests in cool moist ravines. On rock faces and stream banks. Elevation 900 to 1400 feet.
REPRODUCTION: Capsules mature and beginning to open in May. (8 specimens seen, 4 fruiting.)
COUNTIES: Blair, James (A); Bucks, Narrowsville, Porter 5/23/68 (A); Monroe, Pocono, James (C. & A.); Susquehanna, Rushville, 3928; Tioga, Niles Valley 4098, 4081. (5 counties.)

Mnium punctatum Hedw. Common. All physiographic provinces where the proper habitat occurs.

SUBSTRATE: Moist humus and soil, wet rotting wood and moist rock surfaces. pH4 to 7.
HABITAT: In hemlock, mixed hemlock and hardwood forests and rhododendron thickets. Along stream banks and in swampy woods. Elevation 150 to 2000 feet.
ASSOCIATES: *Mnium affine*, *M. cuspidatum*, *Hypnum* spp., *Leucobryum glaucum*, *Sphagnum* spp., *Marchantia* spp., and *Pallavacinia* spp.
REPRODUCTION: Immature sporophytes found as early as September and become 2 cm. long by November. Capsules are mature and open in April and May. (52 specimens examined, 10 fruiting.)
COUNTIES: Berks, Blair, Bucks, Cameron, Center, Chester, Clinton, Cumberland, Franklin, Huntingdon, Lancaster, Lehigh, McKean, Mifflin, Monroe, Northampton, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Sullivan, Susquehanna, Tioga, Venango, Warren. (27 counties). Published, not seen: Elk, McMinn, PC; Pike, Eich's Pond, Moldenke 3337.

Mnium punctatum Hedw., var. **elatum** Schimp. Distinguished from the species by its larger size and the thicker margins to the leaf. Separation at times is an arbitrary matter. Same substrate and habitat preference as the species. Elevation 760 to 1700 feet.

REPRODUCTION: Capsules were present and open on a specimen collected in February. Empty antheridia were found on a plant collected in October. (14 specimens, 1 fruiting.)
COUNTIES: Berks, Lancaster, Lycoming, McKean, Monroe, Northampton, Potter, Schuylkill, Snyder, Sullivan, Union. (11 counties.)

Mnium serratum (Schrad.) Schw. Rare. Local in its distribution. Widely distributed in the northern part of the continent.

SUBSTRATE: Wet rocks and soil.
HABITAT: Wooded stream banks and dark ravines.

REPRODUCTION: Sporophytes 1 cm. long on a specimen collected in November. (10 specimens examined, 1 fruiting.)
COUNTIES: Blair, Bald Eagle Ridge, Porter (C. & A.); Bucks, Nockamixon, Rau 7/1/74 (NY); Lancaster, Martic Forge, James (C) & Porter (A); S. of Lancaster, Tees 653 (A); Monroe, Analomink Creek, James (C. & A.); Delaware Water Gap, Garber, 11/6/68 (A); Northampton, Martins Creek, Schaeffer; Philadelphia, Wissahickon. (6 counties). Published, not seen: McKean, Hawkins and Quintuple 8/2/95, Burnett, J.

Mnium stellare Hedw. Rare. Northern species extending south to Virginia. Principally in the Ridge and Valley and Mountain Provinces.

SUBSTRATE: Soil and rocks. pH 4.
HABITAT: Hardwood and hemlock forests. Stream banks, swampy woods and cool ravines. Elevation 100 to 900 feet.
ASSOCIATES: *Mnium affine* and *M. orthorhynchum*.
REPRODUCTION: Archegonia present, open and brown in color, October 12th. All other material examined was sterile. (15 specimens examined.)
COUNTIES: Berks, Friedensburg, Wilkens 358; Bucks, Rieglesville, Tees 381 (A), Narrowsville, James (C); Delaware, Strath-Haven, Krout 9/15/06; Fayette, Ohio Pyle, Browne (C); Juniata, Cross Keys, 3480; McKean, Burnett 9/9/94. (A); Monroe, Analomink Creek, James 11/63 (A); Northampton, Coffeetown and Martins Creek, Schaeffer, Lime Ridge, Rau 8/73 (A); Philadelphia, Wissahickon, James (C & A); Somerset, Sipesville, Pohl & Lisi; Susquehanna, Rushville, 3928a. (11 counties). Published, not seen: Chester, James, PC.

XII. AULACOMNIACEAE

AULACOMNIUM Schwaegr.

A. Leaf-apex broad, strongly serrate . . . . . *heterostichum.*
A. Leaf-apex acute, serrulate near the tip; propagula usually present . . . *palustre.*

Aulacomnium heterostichum (Hedw.) Bry. Eur. Fairly common. Occurs in all the physiographic provinces of the state.

SUBSTRATE: Soil and humus covered rock surfaces.
HABITAT: Preference for hardwood and hardwood-pine forests. Occasionally under hemlock-hardwood. Found growing near the bottom of wooded north-facing slopes, along stream banks, road banks and shaded moss covered rock ledges. Elevation 150 to 900 feet.
ASSOCIATES: Grows very frequently with *Bartramia pomiformis* as noted by Dr. W. C. Steere, Bryologist 36:14–15. Also with *Mnium*, *Thuidium* and *Cladonia*.
REPRODUCTION: Sporophytes 1 cm. long in November. Mature capsules found open and shedding spores in April. Empty capsules remain on the plants until September. (44 specimens examined, 21 fruiting.)
Type locality: Lancaster, Pennsylvania, Muhlenberg.
COUNTIES: Berks, Bucks, Delaware, Franklin, Fulton, Huntingdon, Lancaster, Lehigh, McKean, Monroe, Montgomery, Northampton, Perry, Philadelphia, Susquehanna. (15 counties). Published, not seen: Chester, James, PC; Lehigh, Rau, PC.

Aulacomnium palustre (Web. & Mohr.) Schwaegr. Uncommon. In all physiographic provinces of the state.

SUBSTRATE: In wet areas on humus, soil, rotting wood and rock surfaces. pH4.
HABITAT: Swampy woods and thickets, marshy old fields at base of grass and wooded creek banks. Elevation 50 to 1820 feet.
ASSOCIATES: In the shade of grass and cattails. Growing mixed with *Sphagnum* spp., *Leucobryum glaucum*, *Mnium affine*, *Polytrichum commune*, and *Helodium paludosus*.

REPRODUCTION: Propagula present in all material examined. Capsules rare, open in June. Young sporophytes 1 to 1.5 cm. long in March. (25 specimens examined, 4 fruiting.)
COUNTIES: Adams, Berks, Chester, Clearfield, Delaware, Elk, Franklin, Lebanon, Lehigh, Luzerne, McKean, Monroe, Northampton, Philadelphia, Sullivan. (15 counties). Published, not seen: Lancaster, Safe Harbor, PC; Snyder, Richfield, 7/17/08, J.

XIII. BARTRAMIACEAE

A. Leaf lanceolate to linear-lanceolate . . . . . 1. *Bartramia.*
A. Leaf shorter, ovate-lanceolate . . . . . 2. *Philonotis.*

1. BARTRAMIA Hedw.

A. Leaves linear, from a sheathing scarious base . . . . . *ithyphylla.*
A. Leaves linear, without a sheathing base . . . . . *pomiformis.*

Bartramia ithyphylla Brid. Rare. No recent records.
SUBSTRATE: Soil.
REPRODUCTION: Immature capsules in May. Capsules open in July material.
COUNTIES: Bucks, Narrowsville, James. July 1871 (A); Fayette, Knipe, May 1871, James Herb. (A).

Bartramia pomiformis (L.) Hedw. Rather common. Widespread.
SUBSTRATE: Soil, shaley talus slopes, rock surfaces (Shale and sandstone).
HABITAT: More commonly found in mixed hardwoods and hardwood-pine. Does occur under hemlock and mixed hemlock-hardwoods. Ravines, steep hillsides, road-banks, north-facing slopes of shale bluffs and on serpentine barrens. Elevation 150 to 1400 feet.
ASSOCIATES: Very frequently with *Aulacomnium heterostichum.* Also *Thuidium delicatulum*, *Leucobryum glaucum* and *Plagiothecium* spp., *Buxbaumia aphylla* collected growing out of a clump of this moss.
REPRODUCTION: Mature antheridia and archegonia found present in June. Capsules are open and shedding spores in late April and early May. Old capsules persist on the plants until September. (48 specimens examined, 29 fruiting.)
COUNTIES: Berks, Bucks, Chester, Clinton, Columbia, Dauphin, Delaware, Franklin, Fulton, Huntingdon, Lancaster, Lehigh, Lycoming, McKean, Montgomery, Northampton, Perry, Philadelphia, Sullivan, Susquehanna, Tioga, York. (22 counties). Published, not seen: Elk, Dent's Run, 7/19/04 J.; Monroe, Porter, PC; Pike, Rau, PC.

2. PHILONOTIS Brid.

A. Perigonia gemmiform, often appearing lateral . . . . . *longiseta.*
A. Perigonia discoid, terminal . . . . . B.
B. Leaf-cells papillose only at upper end . . . . . C.
B. Leaf-cells papillose at lower end, rarely at upper or both ends . . *fontana.*
C. Leaf-cells linear; leaves triangular-lanceolate to ovate-lanceolate . . *marchica.*
C. Leaf-cells oblong to oblong-linear, broader; leaves ovate-lanceolate *Muhlenbergii.*

(*Philonotis calcarea* (Bry. Eur.) Schimp. Excluded species. Not definitely known from North America. Published records: Huntingdon, Warrior's Ridge, Porter PC; Clinton, Renovo J.)

Philonotis fontana (Hedw.) Brid. Fairly common.
SUBSTRATE: Wet soil, logs and rocks.
HABITAT: Eastern hemlock forest. Around springs, ditches, dripping cliffs and falls. Elevation 100 to 2000 feet. (14 specimens.)

COUNTIES: Bucks, Delaware, Lycoming, McKean, Monroe, Northampton, Philadelphia, Susquehanna. (8 counties). Published, not seen: Center, Matternville Gap J; Chester, James PC; Clinton, Hyner Run J; Huntingdon, Huntingdon J; Lancaster, Muhlenberg TM.

Philonotis fontana (Hedw.) Brid., var. **falcata** Brid. Differs from the species in having all of the leaves falcate.

COUNTIES: Clearfield, Columbia, Susquehanna, Wayne. (4 counties). Published, not seen: Center, Matternville Gap, J.

Philonotis longiseta (Rich.) E. G. Britton. Rare. Eastern Pennsylvania.

COUNTIES: Bucks, Nockamixon, Wolle 1/74 (A); Lehigh, Rockdale, Wolle 1/74 (A); Monroe Delaware Water Gap, Schweinitz (A).

Philonotis marchica (Willd.) Brid. Very rare.

COUNTIES: Lawrence, Slippery Rock, Lesquereux 6/65 (A); Lehigh, Rau (A).

Philonotis Muhlenbergii (Schwaegr.) Brid. Not common. Ravines, wet springy and grassy places.

Type locality: Pennsylvania.
COUNTIES: Delaware, Tinicum Island, Krout 7/6/06; Northampton, Coffeetown, Schaeffer 4/26/47, Pot Rock in Delaware River, Easton, Porter 6/68 (A) and Bethlehem, Rau 5/74 (A); Philadelphia, James 4/57 (A). Published, not seen: Lancaster, Muhlenberg PC.

XIV. TIMMIACEAE

TIMMIA Hedw.

Timmia megapolitana Hedw. Rare. Northern species.

COUNTIES: Lancaster, Porter (A); Northampton, Easton, Porter 1872 (A). Published, not seen: McKean, Burnett PC.

ORDER VI. SPLACHNALES

A. Total length of gametophyte with attached sporophyte less than 1 mm. I. *Ephemeraceae.*

A. Gametophyte alone usually much more than 2 mm. high . . . . . B.
  B. Costa faint in the upper part of leaf; protonema persistent II. *Disceliaceae.*
  B. Costa strong, nearly percurrent to shortly excurrent . . . III. *Funariaceae.*

I. EPHEMERACEAE

A. Capsules with rudimentary operculum; capsule-wall a single layer of cells in thickness . . . . . 1. *Nanomitrium.*

A. Capsules without operculum; capsule-wall two layers of cells in thickness 2. *Ephemerum.*

1. NANOMITRIUM Lindb.

Nanomitrium synoicum (James) Lindb. Very rare.

Type locality: Camden, New Jersey and across the Delaware River near Philadelphia.
COUNTIES: Philadelphia, Moyamensing, James 5/68 (A) and below the Navy Yard, James 8/65 (A).

2. EPHEMERUM Hampe.

A. Leaves ecostate . . . . . *serratum*

A. Leaves costate . . . . . B.

B. Costa ending at apex or below, leaves serrate; stomata scattered over the whole capsule . . . . . *cohaerens.*
B. Costa excurrent . . . . . C.
C. Costa excurrent into a long spinulose awn-like acumination which constitutes the greater portion of the leaf above the capsule . . . . . *spinulosum.*
C. Leaves gradually long-acuminate, strongly serrate at apex . . . *crassinervium.*

Ephemerum cohaerens (Hedw.) Hampe. Rare. On moist clay and sandy soil. Old fields.

COUNTIES: Philadelphia, Moyamensing, James 4/66 (A). Published, not seen: Bucks, James PC; Lancaster PC; Northampton, Bethlehem, Wolle PC.

Ephemerum crassinervium (Schwaegr.) C. Mull. Rare. On moist soil, flood plains. Type locality: Probably Pennsylvania.

COUNTIES: Northampton, Easton, Porter, 11/7/68 (A); Philadelphia, Moyamensing, James 10/66 (A). Published, not seen: Chester, Darlington TM; Delaware, Smith, TM; Lehigh, Rau TM; Lancaster, Muhlenberg TM.

Ephemerum serratum (Hedw.) Hampe. Rare. On moist bare soil. Old fields.

COUNTIES: Bucks, James (A); Chester, Coventry, James 12/50 (A) and James 4/51 (A); Philadelphia, James, Musci Appal. Austin (A). Published, not seen: Lancaster, Muhlenberg TM.

Ephemerum spinulosum Schimp. No specimens seen.

Published records: Lehigh, Rau PC; Northampton, Bethlehem, Rau PC; Philadelphia, Moyamensing, James PC.

II. DISCELIACEAE

DISCELIUM Brid.

Discelium nudum (Dicks.) Brid. Rare. On bare clayey soil.

COUNTIES: Lehigh, Rau (A); Northampton, Bingen, Wolle 6/73, Bethlehem, Rau 3/94 and Bethlehem, Musci Appal. Austin (A).

III. FUNARIACEAE

A. Capsule immersed . . . . . 1. *Aphanorrhegma.*
A. Capsule exserted . . . . . B.
B. Capsule symmetrical, urn-shaped . . . . . 2. *Physcomitrium.*
B. Capsule asymmetrical, elongated . . . . . 3. *Funaria.*

1. APHANORRHEGMA Sull.

A. Exothecial cells strongly collenchymatous, line of dehiscence clearly marked *serratum.*
A. Exothecial cells thin-walled, not collenchymatous; line of dehiscence not clearly marked as a rule . . . . . *patens.*

Aphanorrhegma patens (Hedw.) Lindb. Rare. On damp clayey soil.

COUNTIES: Delaware, Strath-Haven, Krout 7/21/08. Published, not seen: Lancaster, Muhlenberg PC.

Aphanorrhegma serratum (Hook. & Wils.) Sull. Rare. On damp clayey soil. Serpentine barrens.

COUNTIES: Franklin, Mercersburg, Porter 8/52 (A); Lancaster, New Texas, Porter 2/94; Northampton, Bethlehem, Rau 1875 (A) and Easton, Porter 11/10/68 (A); Philadelphia, James 1860 (A). Published, not seen: Chester, James PC; Delaware, James PC; Lehigh, Rau PC; McKean, Burnett PC.

2. PHYSCOMITRIUM Brid.

A. Capsule immersed . . . . . *immersum.*
A. Capsule on long seta . . . . . *turbinatum.*

Physcomitrium immersum Sull. Not common. On damp soil, often along river banks.

COUNTIES: McKean, East Branch, Burnett 6/10/95 (A); Philadelphia, Moyamensing, James 10/68 (A) and banks of Delaware, Musci Appal. Austin (A). Published, not seen: Dauphin, Harrisburg, Small PC; Lancaster, Muhlenberg TM.

Physcomitrium turbinatum (Mx.) Brid. Very common. Widespread.

SUBSTRATE: Bare earth, cinders, rock surfaces and mortar. pH5 to 7.
HABITAT: Grassy open woods, gardens, and old fields. Stream banks, hillsides, lawns, flower borders, stone walls and pavements.
ASSOCIATES: *Ditrichum* spp., *Funaria hygrometrica*, *Trematodon* spp.
REPRODUCTION: Immature capsules appear in early March. Mature capsules, open and shedding spores in May and June. (44 specimens, 35 fruiting.)
COUNTIES: Adams, Berks, Bucks, Chester, Delaware, Franklin, Huntingdon, Lehigh, Montgomery, Northampton, Philadelphia, York. (12 counties). Published, not seen: Lancaster, Muhlenberg PC and Small PC; McKean, Bradford, Burnett PC; Somerset, Ursina J.

3. FUNARIA Hedw.

A. Leaves long acuminate, costa excurrent in some leaves of each plant . . . . B.
A. Leaves short acuminate, costa percurrent, sometimes very shortly excurrent *hygrometrica.*
B. Capsules curved and unsymmetric but scarcely cernuous; annulus lacking *Muhlenbergii.*
B. Capsules plainly cernuous, annulus large . . . . . *flavicans.*

Funaria flavicans Mx. Uncommon. More southern in general distribution. Widespread.

SUBSTRATE: Soil and cinders.
HABITAT: Open woods and waste places.
ASSOCIATES: *Funaria hygrometrica.*
COUNTIES: Adams, Arendtsville 5779; Delaware, Swarthmore, Wherry 4/16/46; Lehigh, Allentown, Pretz 13631 (A); Northampton, Weygat, James 4/65 (A); Philadelphia, Byberry, James (A), Pennypack, Krout 8/25/08. Published, not seen: Lancaster, Muhlenberg and Small, PC.

Funaria hygrometrica Hedw. Common. Widespread.

SUBSTRATE: Soil, ashes, cinders, rotting wood and humus covered rocks. pH6 to 8.
HABITAT: Woods, old fields and waste places. Gardens, roadsides, fields, dumps, stonewalls, city streets, curbings, and ditches. Elevation 100 to 1680 feet.
ASSOCIATES: *Funaria flavicans*, *Bryum* spp., *Trematodon longicollis*, and *Hypnum* spp.
REPRODUCTION: Young sporophytes 1 to 1.5 cm. long in March. Mature capsules open in late May and early June. (59 specimens, 33 fruiting.)
COUNTIES: Adams, Berks, Bucks, Chester, Delaware, Elk, Huntingdon, Lancaster, Lehigh, Luzerne, McKean, Monroe, Montgomery, Northampton, Philadelphia, Potter, Somerset, Sullivan, York. (19 counties). Published, not seen: Cambria, St. Lawrence J; Carbon, Rau PC.

Funaria Muhlenbergii Turn. Rare. No specimens seen.

Type locality: Pennsylvania, Muhlenberg.
Published records: Bucks, Narrowsville PC; Lancaster, Muhlenberg PC.

ORDER VII. POLYTRICHALES

A. Terminal gemmae surrounded by a leafy cup present in the gametophytes; capsules with 4 peristome teeth . . . . . I. *Tetraphidaceae.*

A. Gemmae not present; capsule with 16 or more teeth . . . . . B.

B. Leaves of gametophytes with lamellae; capsules on long setae, symmetric II. *Polytrichaceae.*

B. Leaves of gametophyte without lamellae; capsules large not symmetric, immersed or on medium length setae . . . . . C.

C. Annual mosses. Gametophyte rudimentary, capsules oblique on rough setae III. *Buxbaumiaceae.*

C. Perennial mosses. Gametophyte developed, capsules immersed in perichaetium . . . . . IV. *Diphysciaceae.*

I. TETRAPHIDACEAE

Tetraphis Hedw.

Tetraphis pellucida Hedw. Fairly common. In all the physiographic provinces, wherever the proper habitat occurs.

SUBSTRATE: Almost exclusively on rotten wood and humus. It has been collected growing on soil and conglomerate rock. pH4.

HABITAT: Under dense growth of hardwoods and conifers, usually along stream banks, in cool damp ravines, rhododendron thickets or swamps. It has been found at the base of stumps, trees, old logs and boulders, frequently under some larger species of moss. At elevations from 150 to 1940 feet.

ASSOCIATES: Prefers to grow under larger mosses such as *Mnium hornum*, *Dicranella heteromalla*, *Dicranodontium denudatum*, *Thuidium delicatulum* and *Hypnum* spp.

REPRODUCTION: Commonly reproduces by brood bodies called gemmae. These have been found present in material collected from July to January. Mature capsules shedding spores were found in May and June. The empty capsules remain on the plants until October. Young sporophytes 1 cm. long were collected on September 8th. (27 specimens examined, 15 fruiting.)

COUNTIES: Bedford, Berks, Carbon, Delaware, Elk, Lehigh, McKean, Monroe, Northampton, Philadelphia, Potter, Sulivan, Union, Warren, York. (15 counties.) Certainly more widespread but overlooked because of its size and habits of growth. Published, not seen: Bucks, Brownsburg, Tees 344, TM; Center, Scotia, Jennings 9/22/09, J; Chester, James, PC; Franklin, Small, PC; Lancaster, Small, PC; Pike, Rau, PC and Moldenke 3339.

II. POLYTRICHACEAE

A. Calyptra not densely hairy: capsules cylindrical . . . . . 1. *Atrichum.*

A. Calyptra densely hairy: capsule angular or cylindrical . . . . . B.

B. Capsule cylindrical: gametophytes small . . . . . 2. *Pogonatum.*

B. Capsule longitudinally ridged: large gametophytes . . . . 3. *Polytrichum.*

1. Atrichum Beauv. (Catharinea Ehrh.)

A. Leaves ovate-elliptical or obovate: lamellae few and small or lacking . *crispum.*

A. Leaves lanceolate to ligulate: lamellae many and conspicuous . . . . . B.

B. Leaves papillose, costa and lamellae ¼ to ⅔ the width of the leaf at the middle . . . . . *Macmillani.*

B. Leaves not papillose . . . . . C.

C. Costa and lamellae narrower than 1/5 of width of leaf at the middle *undulatum.*

C. Costa and lamellae ¼ to ⅔ the width of the leaf at the middle *angustatum.*

Atrichum angustatum (Brid.) Bry. Eur. The status of this species in North America is open to question. All material I have examined has proved to be *A. Macmillani.* Many specimens in herbaria are labelled *A. angustatum* but all have been worked over carefully and found to have papillae on the leaves. Dr. W. C. Steere has intimated to me that we have no true *A. angustatum* in this country. A thorough study of all available material is certainly essential to establish the true relationship of this species and *A. Macmillani.*

Atrichum crispum (James) Sull. Not common. More frequently found in the Coastal Plain and Piedmont, but occurs in the mountains and plateau region along the water courses.

SUBSTRATE: Soil. Sometimes on badly rotted wood. Within a pH range of 4 to 5.
HABITAT: In shade, principally in the hardwood forests, but occasionally under hemlock and pine. Usually considered a Coastal Plain species but found along the rivers and extending up into the mountains along their tributaries. Collected at elevations ranging from 50 to 1940 feet.
ASSOCIATES: Found growing with *Mnium affine*, *Pohlia nutans*, *Anthoceros* spp. and *Sphagnum* spp.
REPRODUCTION: Mature antheridia found in April. Immature sporophytes occur in material collected in September. Mature capsules are found in November. Empty capsules are still present in April. (34 specimens examined, 6 fruiting.)
COUNTIES: Berks, Bucks, Cambria, Chester, Clearfield, Clinton, Columbia, Dauphin, Delaware, Elk, Lancaster, Lycoming, McKean, Monroe, Montgomery, Northumberland, Philadelphia, York. (18 counties.)

Atrichum Macmillani (Holz) Frye. Common. More common than formerly supposed as many specimens in the Herbaria labelled as *A. angustatum* (Brid.) Bry. Eur. prove to be papillose upon examination.

SUBSTRATE: On a wide variety of soils. Occasionally on rock surface. The pH range is from 4 to 7, principally from 4 to 5.
HABITAT: In the drier portions of the mixed hardwood forests, but also under pine and hemlock. Collected from wooded hillsides, roadsides, sometimes in old fields and pastures. Less frequently along water courses. At elevations from 100 to 2200 feet.
ASSOCIATES: With *Thuidium delicatulum*, *Hypnum* spp., *Cladonia* spp. principally, but grows with a wide variety of mosses and lichens.
REPRODUCTION: Sporophytes first appear in July. Mature closed capsules were found late October through December. The capsules were open and spores were found in the January specimens. (129 specimens examined, 86 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Carbon, Center, Chester, Clinton, Columbia, Cumberland, Dauphin, Delaware, Franklin, Fulton Huntingdon Juniata, Lancaster, Lebanon, Lehigh, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Potter, Somerset, Sullivan, Susquehanna, Tioga, Warren, Wayne, York. (37 counties). Published, not seen: Bedford, Wills Mountain, near Hyndman, 10/9/04, J.

Atrichum undulatum (Hedw.) Beauv. Fairly common. Occurs in all the physiographic provinces of the State.

SUBSTRATE: On sandy and clayey soil. Rarer on rotten wood and exposed rock surfaces.
HABITAT: All types of woodland within the State. Found in the more moist situations such as lowlands along streams, swampy thickets, cool shaded ravines, drainage ditches along roads and marshy old fields and pastures. Collected at elevations from 100 to 2000 feet.
ASSOCIATES: Commonly with species of *Hypnum* and *Mnium.*
REPRODUCTION: The sporophytes are first visible in August. By September they are from 2 to 2.5 cm. long. Open capsules shedding spores were collected in January.

Spores were still present in capsules collected as late as the 25th of April. Empty capsules remain on the plants until September. (97 specimens examined, 20 in fruiting condition.)
COUNTIES: Adams, Berks, Bucks, Carbon, Chester, Columbia, Dauphin, Elk, Fayette, Franklin, Huntingdon, Juniata, Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Sullivan, Susquehanna, Tioga, Venango, Warren, Wayne, Westmoreland, York. (32 counties). Published, not seen: Clinton, Hyner, 7/15/08 J.; Delaware, Smith, TM.

Atrichum undulatum (Hedw.) Beauv., var. **Selwynii** (Aust.) Frye. Distinguished from the species by the length of the lamellae, which are 6–13 cells high. Found on the same type of substrate and in identical habitats as the species. Elevations 550 to 1900 feet.

COUNTIES: Blair, Arch Spring, Proctor 4/19/47; Bradford, Ulster, 3994; Montour, White Hall 5026 and Exchange 5105; Tioga, Mansfield, 4066. (4 counties.)

2. Pogonatum Beauv.

A. Stems branching: plants dark green: capsules smooth, curved . . . . *alpinum.*
A. Stems simple: leaves few: protonema persistent, forming a green felt mass upon which the plants grow . . . . . B.
B Leaves lanceolate-subulate, serrate . . . . . *pensilvanicum.*
B. Leaves lingulate, blunt, entire . . . . . *brachyphyllum.*

Pogonatum alpinum (Hedw.) Røhl. Rare. Occurs only on the Pocono plateau.
SUBSTRATE: Soil and rocks.
HABITAT: Woods and shady places. At higher elevations.
REPRODUCTION: Capsules mature and open in specimens collected in July and September. (7 specimens seen, 3 fruiting.)
COUNTIES: Monroe only, as follows: Canadensis, Porter and James (A); Buckhill Falls, Porter 9/10/69 (NY); Small & Britton 7/13–15/89 (NY); headwaters of Broadhead Creek, Porter 9/10/69 (A & NY). Published, not seen: Chester County in Chester Valley, James, PC.

Pogonatum brachyphyllum (Rich.) Beauv. Rare. Primarily a southern Coastal Plain species.
SUBSTRATE: Soil.
HABITAT: Bare soil in waste places and pine woods.
REPRODUCTION: Capsules found open in April.
COUNTIES: Chester, West Chester, F. Windle 4/3/06. (NY). Published, not seen: Fayette County, Connellsville, Moldenke 3563, det. by Lewis.

Pogonatum pensilvanicum (Hedw.) Paris. Common. Occurs in all the physiographic province of the state.
SUBSTRATE: Eroded clayey soil, gravelly and sandy soil less frequently. pH 4 to 6.
HABITAT: Mixed hardwood forests generally. Occurring usually on eroded road banks or recently deposited alluvium along streams. The densest stand seen was on alluvial clay deposited on the banks of a small stream 1¼ miles southwest of Exchange in Montour County. Elevations from 50 to 2100 feet.
ASSOCIATES: The protonema of this moss forms a rather dense tough cover over the soil, so that masses of it can be collected without crumbling of the clods. An important species in the succession on recently disturbed clayey soil. Its protonema may be the first cover on eroded banks, where it will be followed by *Dicranella heteromalla*, *Marchantia* spp. and *Atrichum Macmillani*. In other instances the lichen *Baeomyces roseus* had been the first to initiate growth, followed by *Pogonatum* and its associates with species of *Cladonia*.

REPRODUCTION: The earliest appearance of sporophytes in collected material was in July, when they averaged 5 to 10 mm. in length. In August some had reached the length of 2 cm. and by September the setae was 3 cm. long. Mature closed capsules were present in November and December. Most of the capsules had opened by January. A few spores were still present in March. Shriveled capsules remained on the plants until May. (78 specimens examined, 55 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Carbon, Center, Clinton, Cumberland, Delaware, Elk, Franklin, Fulton, Huntingdon, Juniata Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Potter, Schuylkill, Sullivan, Susquehanna, Tioga, Union, Warren, York. (33 counties). Published, not seen: Chester, James, PC.

3. POLYTRICHUM Hedw.

A. Leaf margins more or less toothed . . . . . B.
A. Leaf margins entire . . . . . E.
B Marginal cells of lamellae like others in size and thickness of wall; lamellae entire . . . . . C.
B. Marginal cells of lamellae unlike others in size and thickness of wall . . . D.
C. Cells of middle of leaf sheath at ⅔ distance from margin to costa 5.5–9 times as long as wide; at ¾ up the leaf the unistratose margin 2–3 cells wide; epidermal cells of the capsule with or without surface thin spots . . *formosum.*
C. Cells of middle of leaf sheath at ⅔ distance from margin to costa 1.5–4 times as long as wide; at ¾ up the leaf the unistratose margin 4–9 cells wide; epidermal cells of the capsule without surface thin spots . . . . . *gracile.*
D. Marginal cells of lamellae flattopped, not notched or only near leaf margin and base slightly so, capsule elongate . . . . . *ohioense.*
D. Marginal cells of lamellae notched in cross section; capsule cuboidal *commune.*
E. Marginal cells of lamellae pear-shaped in cross section, awn short and reddish . . . . . *juniperinum.*
E. Marginal cells of lamellae pear-shaped in cross section, awn long and hyaline *piliferum.*

Polytrichum commune Hedw. Common, not as abundant as *P. ohioense.* In all the physiographic provinces. Growing in extensive mats.

SUBSTRATE: On all types of acid soil, pioneering on cinders, ash dumps and rocky surfaces. Sometimes covering rotten wood and humus in advance stages of decay. Within a pH range from 4 to 6, but the majority of samples at 4.
HABITAT: Growing in the moister areas of oak, mixed oak-pine and hardwood-hemlock forests. It also invades old fields, thickets, sand-pits, road banks and old railroad beds. It has been collected in alluvial woods along streams and the wooded shores of lakes. At elevations from 50 to 2200 feet.
ASSOCIATES: Found mixed with *Sphagnum* spp., *Hypnum* spp., *Leucobryum glaucum, Dicranum scoparium* and a variety of other mosses. Also with *Cladonia* spp.
REPRODUCTION: Antheridia and archegonia are mature in April. Young sporophytes 5 mm. long were found in November. Mature capsules still covered by the calyptra were collected in June, but by July the capsules were open and shedding spores. Specimens collected in September were found to have a few spores remaining in their capsules. (116 specimens examined, 24 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Cambria, Dauphin, Delaware, Elk, Fayette, Franklin, Huntingdon, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Monroe, Montgomery, Montour, Northampton, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango Warren, Wayne, York. (41 counties). Published, not seen: Cameron, Miller, 7/19/04. J.

Polytrichum commune Hedw. var. **perigoniale** (Mx.) Bry. Eur. Rarer than the species and differing from it in the length of the perichaetial leaves, which are long and thin. In similar but drier situations. From 50 to 2000 feet.

COUNTIES: Bedford, Bradford, Bucks, Cambria, Carbon, Columbia, Cumberland, Delaware, Elk, Jefferson, Luzerne, Monroe, Northampton, Perry, Susquehanna, Wayne, York. (17 counties.)

Polytrichum formosum Hedw. Rare. A species of northern affinities. On soil and humus in the mountains. (4 specimens.)

COUNTIES: Carbon, Frenchtown and Stony Creek, Rau (NY); McKean, Hazelhurst, 5388; Northampton, Monocacy, Rau (NY). (3 counties.)

Polytrichum gracile Smith. Rare. A northern species and difficult to separate from the preceding species. Growing on moist soil and rock surfaces in hardwood forests. (3 specimens.)

COUNTIES: Monroe, Tobyhanna and Naomi Pines, Britton (NY); Philadelphia, Porter (NY). (2 counties.)

Polytrichum juniperinum Hedw. Common. Growing in thick mats. Occurs in all the physiographic provinces.

SUBSTRATE: Soil and rock surfaces. pH4 to 5.
HABITAT: Generally distributed in hardwood, pine-hardwood and pine-forests and old fields. This species occurs in the more sunny situations along lanes and wood roads, in sand-pits, on shale bluffs, mountain tops and bare rocky ledges. At elevations from 50 to 2160 feet.
ASSOCIATES: Growing with other species of *Polytrichum*, *Leucobryum glaucum*, *Dicranum scoparium*, *Hypnum* spp. and *Cladonia* spp.
REPRODUCTION: Antheridia were present and well developed in April. Young sporophytes 5 mm. long were found in September. At this time plants with young sporophytes just appearing and plants with empty capsules were found in the same clump. The capsules mature and shed their spores in June and July. (71 specimens examined, 18 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Cambria, Center, Chester, Columbia, Cumberland, Delaware, Franklin, Fulton, Huntingdon, Lackawanna, Lancaster, Lebanon, Luzerne, Lycoming, McKean, Monroe, Montgomery, Montour, Northampton, Perry, Philadelphia, Pike, Potter, Susquehanna, Tioga, Warren, Wayne, York. (33 counties). Published, not seen: Clearfield, between Clearfield and Pottersdale, 7/13/08 J.; Clinton, near Loch Haven, 7/15/08 J.; Lehigh, Rau, PC.

Polytrichum juniperinum Hedw. var. **alpestre** Bry. Eur. Separated from the species by the presence of numerous matted drity-white rhizoids extending up among the leaves. Many specimens of the species collected show a tendency toward this condition and are difficult to place. Collected on rather wet soil, rich in humus and in sunny situations at elevations of 1400 and 2000 feet. The young sporophytes were 5 mm. long on a specimen collected on the 8th of August. (2 specimens, identification verified by Dr. W. C. Steere.)

COUNTIES: McKean, Hazelhurst, 2554; Perry, New Germantown Hemlocks, 3550.

Polytrichum ohioense Ren. & Card. The commonest species of the genus in the State. Found in all the physiographic provinces.

SUBSTRATE: Soil. Also found on old logs, humus and humus accumulated on rock surfaces. pH4.
HABITAT: Usually growing in hardwood forests, but found also under pine and hemlock. It is abundant on wooded hillsides, in thickets, along trails and wood roads, on shale cliffs and serpentine barrens. It grows in huge mats with other mosses, quite often at the base of trees or sandstone boulders. Elevations from 50 to 2320 feet.

ASSOCIATES: Found growing with other species of *Polytrichum*, *Atrichum Macmillani*, *Leucobryum glaucum*, *Dicranella heteromalla*, *Dicranum scoparium*, *Hypnum imponens*, *Thuidium delicatulum* and *Cladonia* spp.
REPRODUCTION: Mature antheridia were present in April. Young sporophyte plants 5 mm. long were first visible in August. Growth appears to be slow since specimens collected in November had sporophytes averaging 8 to 10 mm. in length. By April the sporophytes were found to have reached the length of 4 or 5 cm. and in June were 7 cm. long, mature and still covered by calyptra. Spores were being shed in July and by late August the capsules were empty. Old capsules remained attached to the plants until November. (138 specimens examined, 72 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bucks, Cambria, Center, Chester, Clearfield, Clinton, Columbia, Cumberland, Dauphin, Delaware, Elk, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Union, Warren, Wayne, York. (41 counties.)

Polytrichum piliferum Hedw. Not common. Ridge and Valley province, Allegheny Mountains and Plateau.

SUBSTRATE: Stony and sandy soil and rock outcroppings. Generally on shale and sandstone rocks. pH4.
HABITAT: Scrub forest types, such as the oak-pine-cedar community found on shale bluffs and the scrubby mixed hardwood forests of the mountain tops. Usually found on the drier stony, south-facing slopes, mountain summits and dry wooded road banks. From 50 to 2000 feet.
ASSOCIATES: On the shale bluffs in the southwestern part of the State it grows associated with the lichen *Cetraria islandica* and *Cladonia rangiferina* and the mosses *Leucobryum glaucum*, *Dicranella heteromalla* and *Atrichum Macmillani*. This group is characteristic of every bluff occurring in Braillier shale. In the second-growth oak forests of the mountain tops and slopes it is associated with the above named species of mosses, plus *Dicranum scoparium*. Other species of *Cladonia* replace the two species of lichens named above.
REPRODUCTION: Antheridia were present on plants collected in April. New sporophytes had grown to a length of 5 mm. in an October collection. Sporophytes are rare in this species. (20 specimens examined, 1 fruiting.) Type locality: Lancaster, Muhlenberg.
COUNTIES: Bedford, Hopewell 5151, New Bueno Vista 5339, Chaneysville 5289; Clinton, Carroll 4903; Dauphin, Halifax 5478a; Delaware, Ridley Quarry, Krout; Fulton, Warfordsburg 4770; Indiana, Saltzburg, Burnett 491 (NY); Lehigh, Mosserville, Schaeffer 11/28/47; Lycoming, Collomsville 4858; McKean, Bennett Brook & Bolivar, Burnett (A); Monroe, Delaware Water Gap, Knipe (A); Northampton, Slateford, Schaeffer; Philadelphia, Germantown, James (A); Schuylkill, Hecla, Wagner 32; Somerset, Sand Patch, Pohl & Lisi. (14 counties). Published, not seen: Chester, James, PC; Lancaster, Porter and Muhlenberg, PC.

III. BUXBAUMIACEAE

BUXBAUMIA (Hall.) Hedw.

Buxbaumia aphylla Hedw. Not common. Majority of collections in the Piedmont and Ridge and Valley Provinces. A few records from the Allegheny Mountains and Plateau.

SUBSTRATE: Clayey soil and sandy loam. A few records on rotten wood and humus.
HABITAT: Open hardwood forests, at the roots of shrubs, on road banks and on wooded slopes. Seems to prefer north facing slopes. At elevations from 150 to 800 feet.
ASSOCIATES: Growing with *Dicranella heteromalla*, *Atrichum Macmillani*, *Bartramia pomiformis*, and species of *Cladonia*.

REPRODUCTION: Capsules mature and closed in November. April collections open and spores still present. (14 specimens.)
COUNTIES: Berks, Vinemont, Wilkens 21; Franklin, Mt. Alto, Edwards 4/20/35; Huntingdon, Three Springs, 5520a; Lehigh, Mountainville, Rau 5/29/72 (NY); Monroe, Delaware Water Gap, Knipe 1874 (C), Porter 11/68 (NY), Garber 11/8/68 (NY), Mt. Pocono, Porter 5/24/00 (NY); Northampton, Easton, Stultz, 5/15/95 (P. & NY), Bethlehem, Wolle 3/28/74; Philadelphia, Wissahickon, James 4/8/64 (C); Schuylkill, Hometown, Wagner 54. (8 counties). Published, not seen: Cameron, Burnett, PC; Chester, South Hills, Everhart and West Chester, F. Windle Bryologist III; Delaware, Crum Creek, Bryologist IV and Cresson 4/27/03, Bryologist VII; Lancaster, Muhlenberg, TM.

IV. DIPHYSCIACEAE

DIPHYSCIUM Mohr.

Diphyscium foliosum (Hedw.) Mohr. Not common. Scattered on soil, usually among other mosses. Piedmont, Ridge and Valley and Allegheny Mountain Provinces.
SUBSTRATE: Soil, usually sterile sandy soil. Occasionally on dry sandstone or shale rocks where humus has accumulated. pH4–5.
HABITAT: In shade of hardwood forests, usually oak-hickory. Frequently along old wood roads and foot paths. At elevations from 100 to 2200 feet.
ASSOCIATES: *Dicranella heteromalla* and species of *Cladonia.*
REPRODUCTION: Immature capsule on material collected as early as May 10th. Earliest date for open capsules producing spores, June 30th. Peak of spore release in July and August with some capsules still containing spores until November 30th. Shrunken capsules persistent until the following April. (40 specimens, 31 fruiting.)
COUNTIES: Berks, Bucks, Carbon, Chester, Dauphin, Delaware, Fayette, Lancaster, Lebanon, Lehigh, McKean, Monroe, Montgomery, Northampton, Philadelphia, Schuylkill, Somerset, Wayne, Westmoreland, York. (20 counties). Published, not seen: Center, Tussey's Mountain, J.

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NORTH QUEENSLAND MOSSES COLLECTED BY L. J. BRASS

Edwin B. Bartram

Bushkill, Pike Co., Penna.

The mosses listed below are the result of the activities of Dr. L. J. Brass in connection with the 1948 Archbold Cape York Expedition.[1] The list gives a very comprehensive idea of the moss flora of the Cape York Peninsula and likewise is an interesting and significant supplement to the information tabulated a few years ago by Mr. H. N. Dixon.[2]

The series includes six new species: *Fissidens terrae-reginae, Fissidens subkurandae, Campylopus Brassii, Dicranoloma spiniforme, Leucoloma circinatulum* and *Ectropothecium riparioides* supplemented by the following nine species not previously recorded from Australia as far as I know: *Bryobrothera crenulata, Himantocladium plumula, Calyptothecium caudatum, Thuidium Meyenianum, Warburgiella cupressinoides, Taxithelium instratum, Taxithelium petrophilum, Isopterygium minutirameum* and *Ectropothecium sandwichense.*

The affinities of these new records and new species are principally with the tropical regions to the north indicating that the moss flora of the Cape York Peninsula has a stronger and more logical bond with these areas than with continental Australia.

Unless otherwise noted the collector is Dr. L. J. Brass. One series including the types of all the new species is in my herbarium. Further distributions will no doubt be made to the Farlow Herbarium, the University of Michigan and elsewhere.

FISSIDENTACEAE

Fissidens (Crispidium) **terrae-reginae** Bartr. sp. nov.

Caules gregarii, usque ad 3 mm. alti, lutescenti-virides. Folia conferta, sicca valde circinato-contorta, ad 2 mm. longa, lineari-lanceolata, anguste acuminata; lamina dorsalis ad basin costae enata; marginibus ubique elimbatis, minutissime crenulatis; cellulae minutissime, 5–7 μ, irregulariter hexagonae, minute papillosae. Fructus terminalis, seta 3–4 mm. longa, theca parva, inclinata.

Mossman River Gorge, on granite rock in rain forest, alt. 150 m., Mar. 16, 1948, No. 18183. Upper Parrot Creek, Annan River, moist rocks on bank of a stream in rain forest, alt. 350 m., Sep. 5, 1948, No. 20037.

This species is very near *F. sylvaticus* Griff. but seems to be distinct in the narrower, more sharply pointed leaves with the lower leaf cells of the duplicate blades often rectangular and to 25 μ long by 10 μ wide.

[1] Collections of the 1948 Archbold Cape York Expedition, American Museum of Natural History, Mr. Leonard J. Brass, Leader. Distributed by the Arnold Arboretum, Harvard University.

[2] Additions to the Mosses of North Queensland. — Proc. Royal Soc. Queensland 53 [2]: 23-40. 1941.

Fissidens (Aloma) **subkurandae** Bartr. sp. nov.

Plantae gregariae, humillimae, virides. Caulis ad 4 mm. longus, laxe foliosus, folia usque ad 12 juga, sicca leniter homomalla, circa 1 mm. longa, oblongo-lanceolata, acuminata; marginibus minutissime crenulatis, ubique elimbatis; lamina dorsalis ad basin costae enata; cellulae pellucidae, irregulariter hexagonae, laeves, diam. 10–15μ. Fructus terminalis; seta 2–2.5 mm. longa; theca erecta.

Leo Creek, Upper Nesbit River: clay mortar of an old stonework forge in rain forest, alt. 420 m., Aug. 18, 1948, No. 19928.

F. kurandae Broth. & Watts is obviously closely related to the above species but, to judge from the description, is a more robust, corticolous plan with longer stems and more bluntly pointed leaves. In *F. subkurandae* the leaves are rather sharply acuminate and not at all "obtiuscula apiculata."

DICRANACEAE

Dicranella pycnoglossa (Broth.) Par.

Mossman River Gorge: wet shaded bank of river, alt. 100 m., Mar. 16, 1948, No. 18194. Shiptons Flat: shady road bank in savanna-forest, alt. 300 m., Sep. 5, 1948, No. 20022. Upper Parrot Creek, Annan River; clayey road in rain forest, alt. 350 m., No. 20034; moist rocks on bank of a stream in rain forest, No. 20036, 20038.

Campylopus introflexus (Hedw.) Brid.

Mt. Finnegan: cushioned on rocks on summit, alt. 1140 m., No. 20138.

Campylopus Wattsii Broth.

Upper Parrot Creek, Annan River: covering an exposed rock outcrop in rain forest, alt. 500 m., No. 20312.

Campylopus Brassii Bartr. sp. nov.

Dioicus, sat robustus, caespitosus, caespitibus densis, lutescentibus. Caulis erectus, dense foliosus, rubrotomentosus; folia sicca imbricata, humida erecto-patentia, rigida, 4–4.5 mm. longa, e basi oblonga sensim subulato-acuminata, caniculato-concava; marginibus erectis, superne serratis; costa cum apice evanida, dorso lamellato, lamellis serratis; cellulis superioribus rhombeis, basilaribus majoribus, ad margines angustis, alaribus numerosis, fuscis. Seta flavida, arcuata; theca oblongo-ovalis, 2 mm. longa; calyptra fimbriata.

Mt. Finnegan: on open ground in high mountain scrub, alt. 1000 m., Sep. 7, 1948, No. 20106.

This species will be distinguished from *C. Wattsii* Broth. by the yellow color, the shorter, rigid leaves and the conspicuous dark brown alar cells not or scarcely auriculate.

Campylopus umbellatus (W. Arn.) Bartr.

Cody Creek, 13 miles WSW of Somerset: on moist sandy soil in black teatree scrub, Apr. 28, 1948, No. 18530 (stunted form). Summit of Mt. Tozer, Tozer Range: seepage-moist places on exposed granite rock faces, July 7, 1948, alt. 540 m., No. 19496.

Holomitrium Muelleri Hpe.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 28, 1948, leg. Austin Vievers, No. 18226. Upper Parrot Creek, Annan River: upper branches of a tall tree in rain forest, alt. 400 m., Sep. 17, 1948, No. 20281. Mt. Finnegan: on corky bark of Casuarina trees in savanna-forest, alt. 800 m., Sep. 21, 1948, No. 20360.

Holomitrium perichaetiale (Hook.) Brid.

Mt. Finnegan: small cushions in tops of trees of stunted high mountain forest, alt. 1060 m., Sep. 21, 1948, No. 20333.

Dicranoloma Menziesii (H. f. & W.) Par.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3500 ft., Mar. 28, 1948, leg. Austin Vievers, No. 18228. Mt. Bellenden-Ker: summit of south peak, on shaded rocks in low forest, alt. 5000 ft., Apr. 6, 1948, No. 18282.

Dicranoloma serratum (Broth.) Par.

Mt. Finnegan: abundant on rocks and lower trunks of trees in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20083.

Dicranoloma austro-scoparium (C. M.) Par.

Mt. Finnegan: on branches of an undergrowth tree in rain forest, alt., 850 m., Sep. 6, 1948, No. 20057; stems of trees in high stunted mountain forest, alt. 1060 m., Sep. 21, 1948, No. 20336.

Dicranoloma spiniforme Bartr. sp. nov.

Caules ad 12 cm. longi, flexuosi, irregulariter ramosi. Folia late patentia, caulina et ramulina superiora valde falcato-secunda, 8–10 mm. longa, e basi ovata, concava sensim setaceo-acuminata; marginibus longe infra apicem spinoso-serratis; costa excurrente, dorso lamellato, lamellis serratis; cellulis linearibus, porosis, alaribus numerosis, magnis, oblongo-rectangularibus, fusco-aureis. Fructus ignotus.

Mt. Finnegan: abundant on undergrowth in high mountain forest, alt. 1100 m., Sep. 7, 1948, No. 20090.

Possibly near *D. Blumii* (Nees) Par. but the leaves shorter, sharply spinose-serrate at least half way down and often nearly to the top of the leaf base.

Leucoloma subintegrum Broth.

Leo Creek, Upper Nesbit River: lower trunk of a tree in rain forest, alt. 500 m., Aug. 18, 1948, No. 19912. Mt. Finnegan: rotting wood in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20096a; on bark of a rotting log in rain forest, alt. 850 m., Sep. 8, 1948, No. 20151a.

Leucoloma (Syncratodictyum) **circinatulum** Bartr. sp. nov.

Dioucum; humile, caespitosum, caespitibus densis, late extensis, superne viridibus, intus fuscescentibus. Caulis usque ad 1 cm. altus, plus minusve ramosus; folia conferta, flexuoso-patentia, superiora congesta, circinato-contorta, ad 3 mm. longa, e basi oblonga sensim subulata; marginibus erectis, superne papiloso-crenulatis, limbata, limbo hyalino, basi latiusculo, superne sensim angustiore, supra medium folii evanido;

costa infra summum apicem evanida; cellulis superioribus minutis, dense papillosis, obscuris, diam. 7-8 μ, basilaribus rectangularibus, laevibus, alaribus numerosis, magnis, rectangularibus, fusco-aureis. Caetera ignota.

Leo Creek, Upper Nesbit River: wet rocks in bed of creek, alt. 420 m., Aug. 17, 1948, No. 19888.

Differs from *L. perviride* Broth. of the Philippines in the crowded comal leaves with circinate points. The upper leaf margins are crenulate with papillae but not serrulate as in the Philippine plants.

Dicnemoloma Sieberianum (Hornsch.) Ren.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 28, 1948, leg. Austin Vievers, No. 18226a.

DICNEMONACEAE

Eucamptodon Mulleri Hpe. & C. M.

Mt. Bellenden-Ker: summit of south peak, on bark of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18279. Mt. Finnegan: on living and dead branchlets in high mountain scrub, alt. 1000 m., Sep. 7, 1948, No. 20108; dead twigs in shrubberies of summit, alt. 1140 m., Sep. 7, 1948, No. 20140; branches of low trees in high mountain scrub, alt. 910 m., Sep. 21, 1948, No. 20356.

LEUCOBRYACEAE

Leucobryum sanctum (Brid.) Hampe

Mossman River Gorge: logs and tree trunks, alt. 100 m., Mar. 17, 1948, No. 18190 in part, 18196. Junction Creek, Russell River: on logs, alt. 50 m., Apr. 2, 1948, No. 18263 in part, 18264, 18265, 18268 in part. Leo Creek, Upper Nesbit River: moist rocks and rotten wood, alt. 420 m., Aug. 17, 1948, No. 19893, 19894a, 19895. Mt. Finnegan: granite rocks and wet banks, alt. 1040 m., Sep. 7, 1948, No. 20084, 20086. Upper Parrot Creek, Annan River: moist stream bank in rain forest, alt. 400 m., No. 20278.

Leucobryum candidum (Brid.) H. f. & W.

Mt. Bellenden-Ker: summit of south peak, on trees of low forest, alt. 5000 ft., Apr. 6, 1948, No. 18284. Tozer Range, ½ mile east of Mt. Tozer: lower trunks of trees in rain forest, alt. 425 m., July 1, 1948, No. 19404a; rotten wood in rain forest, alt. 425 m., No. 19472. Mt. Finnegan: west slopes, on rocks in savanna forest, Sep. 3, 1948, alt. 600 m., No. 20007, a peculiar form with the comal leaves often blunt, broadly margined and congested in a solid, cuspidate tip.

Leucobryum candidum forma **brachyphylla**

Cody Creek, 13 miles WSW of Somerset: on moist sandy soil in black teatree scrub, alt. 10 m., Apr. 28, 1948, No. 18531. Leo Creek, Upper Nesbit River: on rocks and rotten logs in rain forest, alt. 420 m., Aug. 17, 1948, No. 19898, 19938.

Leucobryum candidum var. **pentastichum** (Doz. & Molk.) Dix.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 26, 1948, leg. Austin Vievers, No. 18231, 18229.

Leucobryum ballinense Broth.

Speewah, upper Clohesy River: rotting logs in rain forest, alt. 1500 ft., Mar. 27, 1948, No. 18210 in part. Newcastle Bay, 2½ miles S. of Somerset: on logs and bark, alt. 20 m., May 7, 1948, No. 18656, 18658, 18764. Tozer Range, north end: on bark, alt. 300 m., June 29, 1948, No. 19371. Tozer's Gap, Tozer Range: logs and bases of trees in rain forest, alt. 100 m., June 30, 1948, No. 19383, 19385. Tozer Range ½ mile east of Mt. Tozer: trunks of living trees in rain forest, alt. 425 m., July 1, 1948, No. 19392. Shipton's Flat: on drift logs and charcoal, alt. 275 m., Sep. 4, 1948, No. 20020, 20169. Mt. Finnegan: on rotting logs, alt. 850 m., Sep. 6, 1948, No. 20055.

Leucobryum ballinense Broth. is not a convincing species. The author distinguishes it from *L. brachyphyllum* by the more slenderly acuminate leaves but I believe it will eventually have to be included in the synonymy of the protean *L. candidum* (Brid.) Hpe.

Leucobryum Bowringii Mitt. var. **sericeum** (Broth.) Dix.

Mossman River Gorge: on logs and shaded rocks, alt. 100 m., Mar. 17, 1948, No. 18185, in part, 18191. Mt. Finnegan: rocks on bank of stream in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20081. Shipton's Flat: on moist shady banks of stream, alt. 275 m., Sep. 10, 1948, No. 20168.

Leucophanes candidum (Hornsch.) Lindb.

Mossman River Gorge: forming big bright green cushions on trees overhanging river, alt. 100 m., Mar. 17, 1948, No. 18189.

Leucophanes australe Broth.

Iron River: high on a rain forest tree, alt. 20 m., June 12, 1948, No. 19160 in part.

Octoblepharum albidum Hedw.

Lockerbie, 10 miles WSW of Somerset: dry lateritic rocks on edge of rain forest, alt. 50 m., May 4, 1948, No. 18644. Newcastle Bay, 2½ miles S. of Somerset: lower trunks of trees and logs in scrub of coastal sand dunes, May 7, 1948, No. 18657. Iron Range: high on rain-forest tree, alt. 20 m., June 12, 1948, No. 19160 in part.

CALYMPERACEAE

Syrrhopodon croceus Mitt.

Tozer Range, ½ mile east of Mt. Tozer: lower trunks of trees in rain forest, alt. 425 m., July 1, 1948, No. 19404. Tozer Range, north end: bark of tree on edge of brushy forest, alt. 300 m., June 29, 1948, No.

19372. Leo Creek, Upper Nesbit River: lower trunk of a tree in main forest, alt. 420 m., Aug. 17, 1948, No. 19892.

Thyridium fasciculatum (Hook. & Grev.) Mitt.

Iron Range: on lower trunks of trees in rain forest, alt. 20 m., June 13, 1948, No. 19205. Tozer's Gap, Tozer Range: lower trunks of trees in rain forest, alt. 60 m., July 5, 1948, No. 19456. Leo Creek, Upper Nesbit River: on twigs in rain forest undergrowth, alt. 500 m., Aug. 18, 1948, No. 19913.

Thyridium undulatulum (Broth.) Fleisch.

Lockerbie, 10 miles WSW of Somerset: bark of *Wormia alata* in gallery woods, alt. 30 m., Apr. 30, 1948, No. 18541; in green patches on bark of savanna-forest trees adjacent to rain forest, alt. 50 m., May 4, 1948, No. 18645. Tozer Range, north end: bark of tree in bushy forest, alt. 300 m., June 29, 1948, No. 19370. Tozer's Gap, Tozer Range: on dead wood in rain-forested gully, alt. 100 m., June 30, 1948, No. 19382; trunk of living tree in rain forest, alt. 100 m., July 4, 1948, No. 19440. Tozer Range, ½ mile east of Mt. Tozer: high branches of a tree in rain forest, alt. 425 m., July 6, 1948, No. 19473. Leo Creek, Upper Nesbit River: trunk of a palm in rain forest, alt. 420 m., Aug. 20, 1948, No. 19956, 19872.

Calymperes tenerum C. M.

Newcastle Bay, 2½ miles S of Somerset: dead bark of trees in scrub of coastal sand dunes, May 7, 1948, No. 18670. Tozer Gap, Tozer Range: bark of living tree in rain forest, alt. 60 m., July 5, 1948, No. 19453.

POTTIACEAE

Hyophila involuta (Hook.) Jaeg.

Mossman River Gorge: on wet rocks in river, alt. 100 m., Mar. 17, 1948, No. 18192.

BRYACEAE

Bryum pachytheca C. M.

Hannibal Island, Shelburne Bay: terrestrial in brushy rain forest, alt. c. 1 m., Apr. 19, 1948, No. 18345. Tozer Gap, Tozer Range: on ground where logs have been burned in savanna-forest, alt. 120 m., July 3, 1948, No. 19429, 19524. Brown's Creek, Pascoe River: bare sandy patches in floodbed of creek, alt. 60 m., July 16, 1948, No. 19617.

Bryum subpachypoma Hpe.

Mossman River Gorge: on rocks in rain forest stream, bright green small tufts, alt. 150 m., Mar. 16, 1948, No. 18171; on granite rocks in rain forest, alt. 150 m., Mar. 16, 1948, No. 18175; wet banks of river, alt. 150 m., Mar. 17, 1948, No. 18197.

The distinctions between this species and *B. nitens* Hook. are negligible and I have little doubt but that they are one and the same thing.

RHIZOGONIACEAE

Rhizogonium spiniforme (Hedw.) Bruch

Mossman River Gorge: on log in rain forest, alt. 100 ft., Mar. 17, 1948, No. 18185 in part, 18187, 18190 in part. Speewah, upper Clohesy River: on log in rain forest, alt. 1500 ft., Mar. 27, 1948, No. 18210. Junction Creek, Russell River, on logs in rain forest, alt. 20 m., Apr. 2, 1948, No. 18253, 18263 in part, 18268 in part. Leo Creek, Upper Nesbit River: on log in rain forest, alt. 420 m., Aug. 17, 1948, No. 19890, 19891, 19908, 19927. Tozer Range, ½ mile east of Mt. Tozer: base of dead tree in rain forest, alt. 425 m., July 1, 1948, No. 19391, 19470. Mt. Finnegan: on rocks (granite) in high mountain scrub, alt. 1100 m., Sep. 7, 1948, No. 20087.

Bryobrothera crenulata (Broth. & Par.) Ther.

Mt. Finnegan: on living branchlets of undergrowth in high mountain forest, alt. 1100 m., Sep. 7, 1948, No. 20091.

In studying these plants I was impressed with their resemblance to *Calomnion Dixoni* Bartr. of Fiji. Upon making comparisons they prove to be identical in every respect so *C. Dixoni* must be reduced to synonymy. Instead of being a New Caledonian endemic the species now includes Queensland and Fiji in its geographical range. My Fijian material is all sterile but in habit, appearance and structural detail it is an exact counterpart of No. 110 of Theriot's New Caledonian Exsiccati.

ORTHOTRICHACEAE

Macromitrium Scottiae C. M.

Mt. Bellenden-Ker, summit of south peak: on dead wood of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18280. Mt. Finnegan: on dead branchlets of trees in high mountain scrub, alt. 1100 m., Sep. 7, 1948, No. 20085.

Macromitrium funiforme Dix.

Mt. Bellenden-Ker, summit of south peak: on trees of low forest, alt. 5000 ft., Apr. 6, 1948, No. 18283. Mt. Finnegan: on dead branchlets in high mountain scrub, alt. 1000 m., Sep. 7, 1948, No. 20107.

Macromitrium Daemelii C. M.

Mt. Finnegan: covering dead branches of trees in stunted high mountain forest, alt. 1060 m., Sep. 21, 1948, No. 20334a.

Macromitrium dimorphum C. M.

Mt. Bellenden-Ker, summit of south peak: on trunks of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18281a. Mt. Finnegan: on dead wood and dead branches in shrubberies of summit and high mountain forest, alt. 910–1140 m., Sep. 1948, No. 20136, 20139, 20334, 20358.

Schlotheimia Brownii Brid.

Mt. Bellenden-Ker, summit of south peak: on trunks of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18281b: trunks of trees in stunted high mountain forest, alt. 910 m., Sep. 21, 1948, No. 20357.

RHACOPILACEAE

Rhacopilum convolutaceum C. M.

Leo Creek, Upper Nesbit River: carpeting rocks on side of a bluff in rain forest, alt. 420 m., Aug. 17, 1948, No. 19896.

PTEROBRYACEAE

Mulleriobryum Whiteleggei (Broth.) Fleisch.

Mossman River Gorge: on undergrowth and tree trunks in rain forest, alt. 150 m., Mar. 16, 1948, No. 18172, 18179. Upper Parrot Creek, Annan River: on rocks in bed of stream in rain forest, alt. 400 m., Sep. 17, 1948, No. 20276.

METEORIACEAE

Aerobryopsis longissima (Doz. & Molk.) Fleisch.

Mossman River Gorge: on bark of *Agathis* sp. in rain forest, alt. 150 m., Mar. 17, 1948, No. 18198. Leo Creek, Upper Nesbit River: on trees on open bank of stream in rain forest, alt. 420 m., Aug. 17, 1948, No. 19887; dry twigs in rain forest undergrowth, alt. 500 m., Aug. 18, 1948, No. 19914. Mt. Finnegan: epiphytic in shrubberies of summit, alt. 1140 m., Sep. 7, 1948, No. 20143. Upper Parrot Creek, Annan River: lower trunks of trees in dryish rain forest, alt. 500 m., Sep. 19, 1948, No. 20313.

NECKERACEAE

Himantocladium plumula (Nees) Fleisch.

Iron Range: lower tree trunks in rain forest, alt. 50 m., June 13, 1948, No. 19258.

Calyptothecium recurvulum (C. M.) Broth.

Mossman River Gorge: lower trunks of trees in rain forest, alt. 150 m., Mar. 16, 1948, No. 18176.

Calyptothecium acutum (Mitt.) Broth.

Mossman River Gorge: hanging from granite rocks in rain forest, alt. 150 m., Mar. 17, 1948, No. 18199.

HOOKERIACEAE

Callicostella Kaernbachii Broth.

Wet rocks in rain forest stream, alt. 25 m., Apr. 2, 1948, No. 18255a.

HYPOPTERYGIACEAE

Hypopterygium Daymanianum Broth. & Geh.

Mt. Finnegan: on trunks of trees in high mountain forest, alt. 1100 m., No. 20093.

Hypopterygium Mulleri Hpe.

Mossman River Gorge: shady rocks in rain forest, Mar. 17, 1948, No. 18195. Leo Creek, Upper Nesbit River: carpeting wet rocks in rain forest, alt. 420 m., Aug. 17, 1948, No. 19906.

LESKEACEAE

Thuidium furfurosum (H. f. & W.) Jaeg.

Mossman River Gorge: carpeting rocks in rain forest, alt. 150 m., Mar. 16, 1948, No. 18166.

Thuidium Meyenianum (Hpe.) Bry. Jav.

Rocks and trunks of trees in rain forest, alt. 150 m., Mar. 16, 1948, No. 18169, 18181, 18182. Iron Range: carpeting rocks and logs in a moist rainforest ravine, alt. 40 m., June 16, 1948, No. 19214. Tozer gap, Tozer Range: lower trunks of trees in rain forest, alt. 60 m., July 5, 1948, No. 19445.

Thuidium plumulosiforme (Hpe.) Jaeg.

Mossman River Gorge: on underbrush in rain forest, alt. 150 m., Mar. 16, 1948, No. 18174. Upper Parrot Creek, Annan River: on stones in rain forest, alt. 400 m., Sep. 15, 1948, No. 20256.

ENTODONTACEAE

Trachyphyllum inflexum (Harv.) Gepp.

Lockerbie, 10 miles WSW of Somerset: dry lateritic rocks on edge of rain forest, alt. 50 m., May 4, 1948, No. 18643. Archer River, Wenlock-Coen Road: on dead tree trunks in thin rain forest on banks of river, alt. 125 m., July 31, 1948, No. 19769.

The type collection of *T. papuanum* Broth. came from Thursday Island but as it is very questionably distinct from *T. inflexum* I believe these collections represent the first records for the Australian mainland.

SEMATOPHYLLACEAE

Acanthocladium extenuatum (Brid.) Mitt.

On rotting bark in rain forest, alt. 800 m., Sep. 8, 1948, No. 20154.

Warburgiella cupressinoides C. M.

Mt. Bellenden-Ker, summit of south peak: on bark of *Leptospermum wooroonooran,* alt. 5000 ft., Apr. 6, 1948, No. 18281. Mt. Finnegan: carpeting a rotten log in rain forest, alt. 850 m., Sep. 6, 1948, No. 20056.

Previously known only from the Philippines and New Caledonia.

Sematophyllum caespitosum (Hedw.) Mitt.

Mossman River Gorge: on wet rocks on river bank, alt. 100 m., Mar. 17, 1948, No. 18193. Speewah, upper Clohesy River: on rocks in rain forest stream, alt. 1500 ft., Mar. 26, 1948, No. 18206. Junction Creek, Russell River: on rocks in rain forest stream, alt. 30 m., Apr. 2, 1948, No. 18248, 18256. Iron Range: living bark of trees in floodplain rain forest, alt. 20 m., June 6, 1948, No. 19050. Leo Creek, Upper Nesbit River: on base of tree in rain forest, alt. 420 m., Aug. 15, 1948, No. 19858; rocks on bank of creek in rain forest, Aug. 17, 1948, No. 19897. Upper Parrot Creek, Annan River: on bark of a creek-bank tree in rain forest, alt. 400 m., Sep. 17, 1948, No. 20280.

Sematophyllum saproxylophilum (C. M.) Fleisch.

Leo Creek, Upper Nesbit River: dead trunk of a tree in rain forest, alt. 420 m., Aug. 16, 1948, No. 19873. Mt. Finnegan: on bark of a rotting log in rain forest, alt. 850 m., Sep. 8, 1948, No. 20152. Shipton's Flat: rotten wood in creek-bank rain forest, alt. 275 m., Sep. 4, 1948, No. 20021.

Acroporium erythropodium (Hpe.) Broth.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 28, 1948, No. 18230. Mt. Finnegan: on living branches of trees in high mountain forest, alt. 1100 m., Sep. 7, 1948, No. 20092, 20137, 20332, 20335 in part.

Trichosteleum hamatum (Doz. & Molk.) Jaeg.

Tozer Gap, Tozer Range: on dead logs in a rain forested gully, alt. 100 m., June 30, 1948, No. 19384. Leo Creek, Upper Nesbit River: dead trunk of tree in rain forest, alt. 420 m., Aug. 16, 1948, No. 19873a. Mt. Finnegan: covering trunks of trees in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20082. Upper Parrot Creek, Annan River: on wet decayed wood in a rain forest stream, alt. 400 m., Sep. 17, 1948, No. 20277. Junction Creek, Russell River: on rotting logs in rain forest, alt. 30 m., Apr. 2, 1948, No. 18252 in part.

Acanthorrhynchium papillatum (Harv.) Fleisch.

Leo Creek, Upper Nesbit River: rotten wood, wet rocks and tree trunks in rain forest, alt. 420 m., Aug. 17, 1948, No. 19894, 19894a in part, 19889, 19908a, 19909 in part, 19955. Upper Parrot Creek, Annan River: moist bank of a stream in rain forest, alt. 400 m., Sep. 17, 1948, No. 20279.

This wide ranging species is not uncommon in the Cape York Peninsula to judge from these collections and it seems strange that it has been recorded only once before. It frequently grows in association with *Leucobryum sanctum* both here and elsewhere through the range.

Taxithelium instratum (Brid.) Broth.

Mossman River Gorge: on log in rain forest, alt. 100 m., Mar. 17, 1948, No. 18186a.

A frequent Indo-Malaysian species but not previously known south of New Guinea.

Taxithelium petrophilum Williams

Tozer Gap, Tozer Range: covering stones in flood channel of a stream in rain forest, alt. 60 m., July 5, 1948, No. 19457.

The rupestrine habit, strongly complanate and sharply pointed leaves, the absence of enlarged alar cells and shorter setae are characters in the aggregate which clearly separate these plants from *T. instratum*. After reexamining the Philippine material I believe the reduction of *T. petrophilum* (*petrophila*) to a synonym of *T. instratum* was a mistake. The Queensland collection is similar in every particular to the Philippine type

but is in much better condition so that the distinctions are more sharply defined.

Taxithelium selenithecium (C. M.) Par.

Mossman River Gorge: lower trunk of a tree in rain forest, alt. 150 m., Mar. 16, 1948, No. 18170. Lockerbie, 10 miles WSW of Somerset: covering a stone in rain forest, alt. 50 m., May 4, 1948, No. 18646. Iron Range: on dead bark of trees in floodplain rain forest, alt. 20 m., June 6, 1948, No. 19061. Tozer Gap, Tozer Range: wet rocks in bed of stream in rain forest, July 5, 1948, No. 19454. Coen: in wet shade in rocky bed of Coen River, alt. 200 m., Aug. 3, 1948, No. 19795.

Taxithelium novae-valesiae (Broth.) Broth.

Mt. Finnegan, west slopes: on bark of a rotting log in rain forest, alt. 850 m., Sep. 8, 1948, No. 20151. Mt. Finnegan: rotting wood in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20096; small cushions in tops of trees of stunted high mountain forest, alt. 1060 m., Sep. 8, 1948, No. 20153 in part. Junction Creek, Russell River: on dead wood in rain forest, alt. 50 m., Apr. 2, 1948, No. 18266. Mossman River Gorge: decaying bark in rain forest, alt. 150 m., Mar. 16, 1948, No. 18180. Leo Creek, Upper Nesbit River: on living bark in rain forest undergrowth, alt. 420 m., Aug. 30, 1948, No. 19953.

HYPNACEAE

Isopterygium minutirameum (C. M.) Jaeg. var. **brevifolia** Fleisch. — (*Hypnum austro-pusillum* C. M., Linn. 1871–73, p. 159)

Junction Creek, Russell River: on rotting logs in rain forest, alt. 30 m., Apr. 2, 1948, No. 18252 in part. Tozer Range, ½ mile east of Mt. Tozer: covering a dead stick in rain forest, alt. 425 m., July 1, 1948, No. 19405. Shipton's Flat: moist granite rock on bank of stream, alt. 275 m., Sep. 10, 1948, No. 20170. Upper Parrot Creek, Annan River: on rotten log in rain forest, alt. 400 m., Sep. 19, 1948, No. 20321.

Ectropothecium sandwichense (Hook. & W. Arn.) Mitt.

Mossman River Gorge: on a log in rain forest, alt. 100 m., Mar. 17, 1948, No. 18186. Speewah, upper Clohesy River: rotting log in rain forest, alt. 150 m., Mar 26, 1948, No. 18205. Junction Creek, Russell River: wet rocks in rain forest stream, alt. 25 m., Apr. 2, 1948, No. 18255. Iron Range: decayed wood on rain forest floor, alt. 20 m., June 15, 1948, No. 19204. Leo Creek, Upper Nesbit River: moist rocks of creek banks in rain forest, alt. 420 m., Aug. 17, 1948, No. 19904. Upper Parrot Creek, Annan River: on an old log in rain forest, alt. 500 m., Sep. 15, 1948, No. 20255.

This species probably has a wider distribution than the published records indicate and may eventually acquire a considerable synonymy.

Ectropothecium Moritzii (C. M.) Jaeg.

Leo Creek, Upper Nesbit River: carpeting wet rocks on creek bank in rain forest, alt. 420 m., Aug. 17, 1948, No. 19905; on a seepage-wet rock in rain forest, alt. 420 m., Aug. 17, 1948, No. 19907.

Ectropothecium riparioides Bartr. sp. nov.

Dioicum; gracile, caespitosum, caestipitibus laxis, depressis, viridibus. Caulis elongatus, flexuosus, ad 10 cm. longus, pinnatim-ramosus, ramis ad 1 cm. longis, complanate foliosis. Folia patentia, haud falcata, 0.8 mm. longa, ovato-lanceolata, acuminata, ecostata, superne minute denticulata; cellulis linearibus, laevissimis, alaribus paucis, subquadratis. Caetera ignota.

Junction Creek, Russell River: on shallowly submerged rocks in stream in rain forest, alt. 30 m., Apr. 2, 1948, No. 18251.

Possibly near *E. serrifolium* Broth. & Watts but entirely different in habit and quite distinct in the subentire leaves with smooth cells.

Trachythecium verrucosum (Hpe.) Fleisch.

Mossman River Gorge: lower trunks of trees in rain forest, alt. 150 m., Mar. 16, 1948, No. 18167, 18178.

Addendum

Through the friendly cooperation of Mr. J. H. Willis I have received the mosses listed below which were collected by Dr. Brass and included with the Hepatics sent to the Melbourne Botanic Gardens for study. These are important additions to the moss flora of North Queensland and neither of the species appeared in the original series of moss collections. I am grateful to Mr. Willis for making them available and am happy to be able to include them in the list of mosses collected by Dr. Brass during the course of the expedition.

LEMBOPHYLLACEAE

Camptochaete brisbanica (C. M.) Broth. & Watts.

Mt. Finnegan, west slopes (Cedar Bay S. of Cooktown), abundant on branches of woody undergrowth in rain forest, alt. 850 m., Sep. 8, 1948, No. 20058. Mt. Finnegan, dead twigs in rain forest, alt. c. 800 m., Sep. 8, 1948, No. 20155.

The only record of this species I can locate is in "The Mosses of North Queensland" (Proc. Linn. Soc. of N. S. Wales, Vol. 43, pt. 3, p. 561, 1918). Mr. Wallis tells me that he has compared these collections with material in the National Herbarium, Victoria, determined by Rev. W. W. Watts and finds that they match beautifully.

HOOKERIACEAE

Eriopus Brassii Bartr. sp. nov.

Dioicum ut videtur. Caulis circa 1 cm. longus, simplex vel parce ramosus, laxe foliosus, parce radiculosus. Folia patentia, complanata, ad 2.5 mm. longa, 1.5 mm. lata, e basi angustata late ovata, apice rotundato-obtusa, tenuiter apiculata, ecostata,

ubique limbata, limbo hyalino e cellulis 2–3 seriatis superne remote denticulatis instructo; cellulae superiores ovali-hexagonae, ca. 37 μ longae, 20 μ latae, parietibus firmis, basilares laxiores. Caetera ignota.

Mt. Finnegan, trunk of tree in high mountain forest, alt. ca. 1040 m., Sep. 7, 1948, No. 20097.

Unfortunately the plants I have seen are entirely sterile so that the sporophyte characters which are of high diagnostic value in this genus are lacking. The narrowly bordered leaves and the slender apiculus clearly differentiate this species from *E. apiculatus* (H. f. & W.) Mitt. and the denticulate leaf margins preclude any confusion with *E. Brownii* Dix. of New Zealand. The species of this widely distributed and remarkable genus are in need of a careful revisional study but meanwhile it would seem that the Mt. Finnegan plants are deserving of a definite specific status.

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IDENTIFICATION OF YEASTS FROM COMMERCIAL CUCUMBER FERMENTATIONS IN NORTHERN BRINING AREAS [1]

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Cucumbers for pickling represent an important agricultural commodity — ranking fourth in acreage and sixth in value of all horticultural crops for processing. The annual crop of pickling cucumbers is about 10 million bushels; of this amount, approximately 8 to 8.5 million bushels are brine-cured and the balance goes to fresh-pack or pasteurized products. About one-fourth of the crop is brined in the Southeastern States; and Indiana, Michigan, and Wisconsin brine approximately one-half.

For the past several years this Bureau, in cooperation with the Department of Horticulture of the North Carolina Agricultural Experiment Station, has been investigating the microbiological changes occurring during the fermentation of cucumbers brined under southern conditions. More recently part of this cooperative work has centered around that portion of the fermentation caused by yeast activity. Particular emphasis has been placed on the identity of the individual species comprising the total yeast population. We are interested in obtaining basic information of this type for the major cucumber pickling areas of the country in an effort to improve existing brining procedures and minimize losses caused by (1) enzymatic softening of salt-stock, and (2) the formation of bloaters (hollow salt-stock). Most yeasts of cucumber brine origin possess two important qualities that would be required of any microbial group associated with the two important types of economic loss mentioned above. These qualities are high tolerance to salt and high tolerance to acid.

In a recent report (Etchells and Bell, 1950 *a*), 1,444 yeast isolates associated with the gaseous fermentation of cucumbers under conditions typical of southern brining areas (e.g. North Carolina) were classified. During the period when isolations were made, the brine strength of the fermentations was within the range of 10 to 18 percent by weight. It was found that the isolates could be reduced to the following six genera in the order of frequency of isolation: *Torulopsis*, 721 isolates; *Brettanomyces*, 588; *Zygosaccharomyces*, 59; *Hansenula*, 49; *Torulaspora*, 6; *Kloeckera*,

[1] This study was carried out under a cooperative project with the Department of Horticulture of the North Carolina Agricultural Experiment Station. Published with the approval of the Director, North Carolina Agricultural Experiment Station as Paper No. 383 of the Journal Series.

1; and 20 cultures not fully classified. Bloater formation in the vats of salt-stock cucumbers examined was attributed to the gaseous yeast fermentation. The proportion of bloaters found in seven vats of large-sized cucumbers ranged from 23 to 54 percent.

Although the above study definitely established that certain yeast species were related to bloater formation under southern fermentation conditions, no incrimination of these species has been demonstrated to date (Etchells and Bell, 1951) in connection with the type of enzymatic softening of cucumber salt-stock described by Bell, Etchells, and Jones (1950). However, several yeast species (all from sources other than cucumber brines) have been reported (Luh and Phaff, 1948; Hall and Teunisson, 1948; Etchells and Bell, 1951) as being capable of producing a pectin-splitting enzyme similar to the one responsible for softening of salt-stock (Bell, Etchells, and Jones). Such yeasts, growing in commercial cucumber brines, could contribute materially to the softening type of spoilage. Continued isolation and identification of yeasts from cucumber fermentations in the major brining areas of the country may reveal species capable of glycosidic hydrolysis of pectin.

Previous studies on the yeasts responsible for the gaseous fermentation of cucumbers have been limited to conditions typical of southern states. The present investigation was undertaken (1) to establish whether yeast activity represents a part of the cucumber fermentation under conditions typical of northern brining areas represented by the states of Indiana, Michigan and Wisconsin, and (2) if so, to determine the nature and sequence of the principal yeast species present.

EXPERIMENTAL PROCEDURE

During a 3-year period (1948–50) 155 brine samples were collected from 21 commercial cucumber brining stations, operated by eight pickle companies in Indiana, Michigan, and Wisconsin. The location of brining stations visited in each state, and the number of brining seasons each station was visited, are given in table 1. During the 1948 and 1949 seasons, the brines were collected during the first week in November and represented the middle to late periods of fermentation; during the 1950 season, the samples were taken during September, 4th to 9th, and covered the early period of fermentation. The brine temperatures of the fermentations sampled during the 1950 season were as follows: Indiana brines, 19 to 20°C; Michigan and Wisconsin brines, 15.5 to 20°C. Brine temperatures were not taken during the 1948 and 1949 sampling periods. A total of 452 yeast isolates were obtained during the investigation and information as to their source is presented in table 2. A general picture with respect to total yeast populations, rate of increase in brine strength, and chemical changes with respect to brine acidity and pH, is presented in figure 1. The curves represent mean values for all brines collected during the 3-year period.

TABLE 1. LOCATION OF NORTHERN CUCUMBER BRINING STATIONS FROM WHICH BRINE SAMPLES WERE COLLECTED DURING 1948, 1949, AND 1950.

State	Brining Station	General Location of Station in Each State	Brining Seasons During Which Station Was Visited	
	code	*no.*	*no.*	*yrs.*
Indiana	NJ	North West	3	1948–50
	KR	North West	3	1948–50
	KO	North West	1	1948
State Total		3		
Michigan	LT	South Central	3	1948–50
	LA	South Central	3	1948–50
	CL	Central	2	1949–50
	BA	South West	1	1948
	RD	South Central	1	1948
	SG	East Central	1	1950
	NL	Central	1	1950
	SN	East Central	1	1950
	CS	West Central	1	1950
	LV	West Central	1	1950
	CC	East Central	1	1950
State Total		11		
Wisconsin	BR	Central	2	1948; 50
	WY	Central	2	1948; 50
	PL	South East	2	1948; 50
	WA	Central	2	1948; 50
	OX	Central	1	1948
	GB	East Central	1	1950
	WU	Central	1	1950
	NK	Central	1	1950
State Total		8		
Total		22		

Of the 155 individual vats sampled, about one-third were under outside conditions and the remainder were sheltered from the weather and direct sunlight. Vats so protected afford excellent conditions for good growth of yeast species responsible for film formation on the brine surface (Etchells and Bell, 1950 *b*). More important is the fact that contamination of subsurface brine samples with species of film yeasts can become a problem unless care is taken with the sampling procedure (Etchells and Jones, 1946: Etchells and Bell, 1950 *a*). In the present study, less than 3 percent of the 452 isolates were classified as film yeasts which originated from surface growth on sheltered vat brines. The 12 film yeast isolates (7 *Candida* and 5 *Debaryomyces*) came from seven brines; five were collected during the 1949 season; and two from 1950.

The brine samples were collected, plated, and counted according to methods previously described by Etchells (1941) and revised by Etchells and Jones (1946), and Etchells and Bell (1950 *a*). All brines were plated on acidified glucose agar containing 6 to 8 percent salt by weight and the plates from the high dilutions set aside for picking representative colonies. These colonies were identified and the proportion of each species

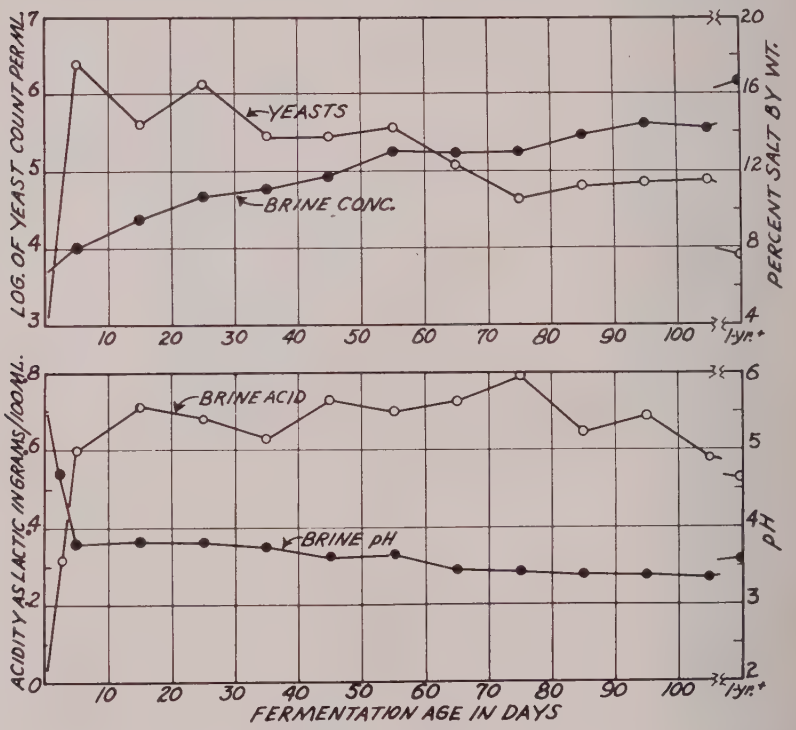

Figure 1. Total yeast populations, increase in brine concentration, brine acidity and pH of northern cucumber fermentations.

present was assigned a value which gave an estimate of their numbers in the brine sample. The methods and classification systems employed for the 452 isolates were essentially those outlined by the Dutch workers; Stelling-Dekker (1931), Lodder (1934), Diddens and Lodder (1942), and Custers (1940). Bedford's (1942) classification system was used for the genus *Hansenula*. For confirming the ability of isolates of certain genera (e.g. *Hansenula* and *Brettanomyces*) to utilize nitrate, the assimilation test of Wickerham (1946, 1951) was particularly useful. Certain other modifications and additions were made in connection with the taxonomic tests employed by the Dutch group. These have been fully described by Etchells and Bell (1950 *a*, *b*).

TABLE 2. ORIGIN OF 452 YEAST ISOLATES FROM 155 CUCUMBER BRINES OBTAINED FROM 22 BRINING STATIONS LOCATED IN INDIANA, MICHIGAN, AND WISCONSIN (1948–50 BRINING SEASONS).

State and Brining Season	Brining Stations Visited [1]	Brine Samples Obtained	Chemical Examination of Brines: Salt Conc. by Wt.	Chemical Examination of Brines: Acidity as Lactic	Chemical Examination of Brines: pH	Fermentation Period Covered by Samplings [2]	Yeast Isolates Obtained
	number	*number*	*percent*	*percent*		*days*	*number*
Indiana							
1948	3	11	13–17	0.46–.88	4.1–3.4	54–97	31
1949	2	21	13–15	.34–.78	3.6–3.2	66–105	56
1950	2	16	4–12	.27–.85	3.9–3.7	4–55	59
	7	48					146
Michigan							
1948	4	20	11–18	0.38–.88	4.2–3.1	39–94	57
1949	3	16	14–17	.52–.83	3.7–3.3	70–98	33
1950	9	32	7–12	.31–.92	4.8–3.6	2–44	97
	16	68					187
Wisconsin							
1948	5	21	11–14	0.62–1.16	3.6–3.2	48–100	58
1949	0	0	....				0
1950	7	18	8–13	.41–.98	4.1–3.6	13–38	61
	12	39					119
Overall	35	155	4–18	0.27–1.16	4.8–3.1	2–105	452

[1] Refers to total number visits to 22 individual brining stations operated by 8 pickle plants and located as follows: Indiana, 3 stations; Michigan, 11; and Wisconsin, 8.

[2] Brine samples were obtained from several vats in Indiana and Michigan during 1948 and 1949 after 12–14 months' storage.

RESULTS

The 452 isolates obtained during the 3-year study were reduced to eight generic groups as follows: I. *Brettanomyces*, 132 isolates (29.2%); II. *Torulopsis*, 103 (22.8%); III. *Torulaspora*, 68 (15.0%); IV. *Hansenula*, 59 (13.1%); V. *Saccharomyces*, s.g. *Zygosaccharomyces*, 46 (10.2%); VI. *Saccharomyces*, s.g. *Saccharomyces* s.s., 22 (4.9%); VII. *Candida*, 7 (1.5%); VIII. *Debaryomyces*, 5 (1.1%); and an unclassified group of 10 isolates. Species separation under each generic group is summarized in table 3. Information is also presented on species distribution for each brining season with respect to: (1) Number of isolates found; (2) number of vat brines where found; and (3) number of brining stations where found.

Predominating Genera

Group I, Genus *Brettanomyces* Kuff. et van Laer: Of the 132 isolates placed in this genus, 103 were identified as *B. versatilis* Etchells et Bell. This yeast was the most frequently isolated species obtained during the study and was widely distributed in the brines collected each season from all three states. *B. versatilis* was also found in several instances where the brine samples came from vats of salt-stock that were 12–14 months old. Twenty-nine isolates were closely related to *B. sphaericus* Etchells et Bell. Until further study can be made of this group, we prefer to list them as an unnamed variety of *B. sphaericus*. Most of these cultures were obtained in Indiana and Michigan during the 1949 and 1950 brining seasons.

Group II, Genus *Torulopsis* Berlese: The 103 cultures placed in this genus consisted of two species: *T. holmii* (Jörgensen) Lodder accounted for 67 cultures which, with the exception of one isolate obtained in 1948, came from brines collected from nine brining stations during the 1950 season. This species occurred chiefly in brines during the early part of the fermentation. The 36 isolates placed as *T. caroliniana* Etchells et Bell were obtained during two brining seasons (1948 and 1950), and came mostly from brines collected at two Indiana brining stations; however, a few cultures were isolated from Michigan brines.

Group III, *Torulaspora* Lindner: The 68 isolates placed in this genus were identified as *T. rosei* Guillermond and were obtained in about equal numbers from brines collected during the 1948 and 1950 seasons. This yeast was not found in the 1949 brines collected in the regular manner. The cultures were identical as far as cultural, morphological, fermentation, and carbon assimilation reactions were concerned, but differed with respect to sporulation behavior. Some sporulated readily; others produced typical copulation tubes but spores did not develop; still others produced neither copulation tubes nor spores.[2]

Group IV, Genus *Hansenula* Sydow: This genus was represented by

[2] Dr. L. J. Wickerham kindly checked representative cultures of our *T. rosei* collection and found the carbon assimilation patterns to be the same.

TABLE 3. CLASSIFICATION AND DISTRIBUTION OF 452 YEAST ISOLATES FROM 155 NORTHERN CUCUMBER BRINES.

Generic Group (Number and Percent of Isolates), and Species	Classification of Isolates		Distribution of Isolates According to: Brining Season			Vat Brines			Brining Stations		
			1948	1949	1950	1948 (52) [1]	1949 (37) [1]	1950 (66) [1]	1948 (12) [2]	1949 (5) [2]	1950 (18) [2]
	no.	*percent*	*no. isol.*	*no. isol.*	*no. isol.*	*no. vats*	*no. vats*	*no. vats*	*no. sta.*	*no. sta.*	*no. sta.*
I. BRETTANOMYCES (132; 29.2%)											
B. versatilis	103	22.8	43	27	33	21	17	19	12	5	8
B. sphaericus var.	29	6.4	0	15	14	0	12	9	0	4	5
II. TORULOPSIS (103; 22.8%)											
T. holmii	67	14.8	1	0	66	1	0	23	1	0	9
T. caroliniana	36	8.0	16	0	20	6	0	7	2	0	3
III. TORULASPORA (68; 15.0%)											
T. rosei	68	15.0	35	0	33	17	0	14	7	0	7
IV. HANSENULA (59; 13.1%)											
H. subpelliculosa	59	13.1	19	24	16	16	15	9	9	4	7
V. ZYGOSACCHAROMYCES s.g. (46; 10.2%)											
Z. halomembranis	28	6.2	7	14	7	4	8	7	2	2	2
Z. globiformis	14	3.1	11	0	3	7	0	2	5	0	1
Z. sp. A	3	0.7	0	1	2	0	1	2	0	1	1
Z. pastori	1	0.2	0	1	0	0	1	0	0	1	0
VI. SACCHAROMYCES s.g. (22; 4.9%)											
S. globosus	22	4.9	13	0	9	6	0	4	4	0	3
VII. CANDIDA (7; 1.5%)											
C. krusei	7	1.5	0	0	7	0	0	2	0	0	2
VIII. DEBARYOMYCES (5; 1.1%)											
D. membran. var. *Holl.*	5	1.1	0	5	0	0	5	0	0	2	0
UNCLASSIFIED	10	2.2	1	2	7	1	1	6	1	1	6
	452	100	146	89	217						

[1] Number of vat brines collected each year; values listed in each column represent the number of brines where each species was found.

[2] Number of individual brining stations visited each year; values listed in each column represent the number of brining stations where each species was found.

59 cultures of *H. subpelliculosa* Bedford, obtained from representative brining stations in Indiana, Michigan, and Wisconsin. This species was consistently found during all three brining seasons. The cultures were divided into two groups; those that fermented maltose, and those that gave a weak to negative fermentation test for this sugar. Etchells and Bell (1950 *a*) considered that the fermentation of maltose was a weak characteristic for this species because of the variable reactions obtained when a sufficient number of cultures were studied. More recently, Wickerham (1951) also found that *H. subpelliculosa* gave a variable maltose fermentation.

Group V, Genus *Saccharomyces* (Meyen) Reess; subgenus *Zygosaccharomyces* Barker; The 46 isolates placed in this subgenus were allocated to the following four species: *Z. halomembranis* Etchells et Bell, 28 cultures; *Z. globiformis* Kr. et Kb., 14; *Z.* species A, 3; and *Z. pastori* Guillermond, 1. The species *Z. halomembranis* was consistently found in the brines of two Indiana stations during the 3-year study. The isolates placed as *Z. globiformis* were similar but not identical to this species. However, the characteristics were essentially the same as those described in detail by Etchells and Bell (1950 *a*) for their *Z.* species A, obtained from the fermentation of cucumbers brined under southern conditions.

Group VI, Genus *Saccharomyces* (Meyen) Reess; subgenus *Saccharomyces* s.s.: This subgenus was represented by 22 cultures of *S. globosus* Osterw. obtained during the 1948 and 1950 seasons from a total of seven brining stations, two in Wisconsin and five in Michigan. This particular yeast constitutes the chief difference with respect to the individual species found in northern brines as compared to those found in southern brines (Etchells and Bell, 1950 *a*). Although *S. globosus* was not found as frequently as certain of the other species, four active gaseous fermentations were attributed to this yeast. They were observed in 1948 at two brining stations in Michigan and one in Wisconsin, in brines that were 43, 44, 99, and 100 days old.

Group VII, Genus *Candida* Berkhout emend. Diddens et Lodder: The seven cultures placed in this genus were identified as *C. krusei* (A. Cast.) Berkhout and came from two 1950 brines of low salt content (4 and 8 percent). The presence of these isolates in the subsurface brine samples is attributed to film formation on the two sheltered vat brines from which they were obtained. This species was found by Etchells and Bell (1950 *b*) to be associated with film formation on commercial pickle brines of about 5 percent strength.

Group VIII, Genus *Debaryomyces* Klöcker: The five isolates of this genus were identified as the film yeast *D. membranaefaciens* var. *Hollandicus* Lodder. The cultures were obtained from five brines collected during the 1949 season at two brining plants in Indiana. The vats at both stations were sheltered from direct sunlight and provided excellent conditions for film yeast development on the surface of the brines. It is our opinion

that the five *Debaryomyces* cultures originated from the surface growth on the brines.

Unclassified Group: Ten of the 452 cultures obtained during the study have not been fully classified. Seven of the unidentified isolates came from six brines of the 1950 season; two were obtained during 1949; and one in 1948.

Populations of Individual Species

The results for the 3-year study with respect to estimated population trends for the different yeast species occurring in the 155 brines are shown in figure 2. In the preparation of these scatter diagrams, the individual values plotted represent the estimated yeast count as to species in the various brines. The general trend for species activity in each case is represented by the curve drawn through the individual values, calculated from means obtained at 10-day intervals throughout the fermentation period.

Two yeasts, *T. holmii* and *B. versatilis*, show rather clear-cut fermentation trends. The first species occurred chiefly during the early portion of the fermentation; the second dominated the late portion. As mentioned earlier, *T. holmii*, with one exception, was not found in the brines collected during the 1948 and 1949 brining seasons. A possible reason for this was that these brines represented the middle to late periods of fermentation (40 days and beyond). Thus, on the basis of the 1950 season's results, *T. holmii* would not be expected to be found in any large numbers in brines that were over 30 to 40 days in age.

The consistent occurrence of *Hansenula subpelliculosa* from brining stations representative of the three states throughout the three pickling seasons is sufficient to include this species as one of the principal species contributing to the yeast fermentation. Perhaps the same is true for *Torulaspora rosei*, even though it was not obtained from brines collected during the 1949 season. However, during 1949, brines were not obtained from Wisconsin (Cf. tables 1 and 2); whereas the four stations sampled in that state during 1948 accounted for almost three quarters of the *T. rosei* isolates obtained from all 12 stations sampled. Further, the fermentation trend (Cf. figure 2) for this yeast is not fully characterized because plate counts were not made on 11 of the 1948 Wisconsin brines where *T. rosei* represented almost 60 percent of the isolations.

The activity of *Zygosaccharomyces halomembranis* in northern brines is based chiefly on consistent isolations of this species from two Indiana stations during the three brining seasons. Etchells and Bell (1950 *b*) identified this yeast as one of the species responsible for films on sheltered commercial vat brines located in Indiana, Michigan and Wisconsin. This species ferments glucose and maltose strongly and it is our opinion that it exists in commercial brines both as an oxidative and fermentative species, thus accounting for its occurrence in subsurface fermenting brines as

well as for its occurrence on the surface of sheltered vat brines. Laboratory tests confirm this assumption.

The dominant position occupied by *Torulopsis caroliniana* in the early portion of southern cucumber fermentations (Etchells and Bell, 1950 *a*) is in sharp contrast to the relatively minor role exhibited by this species

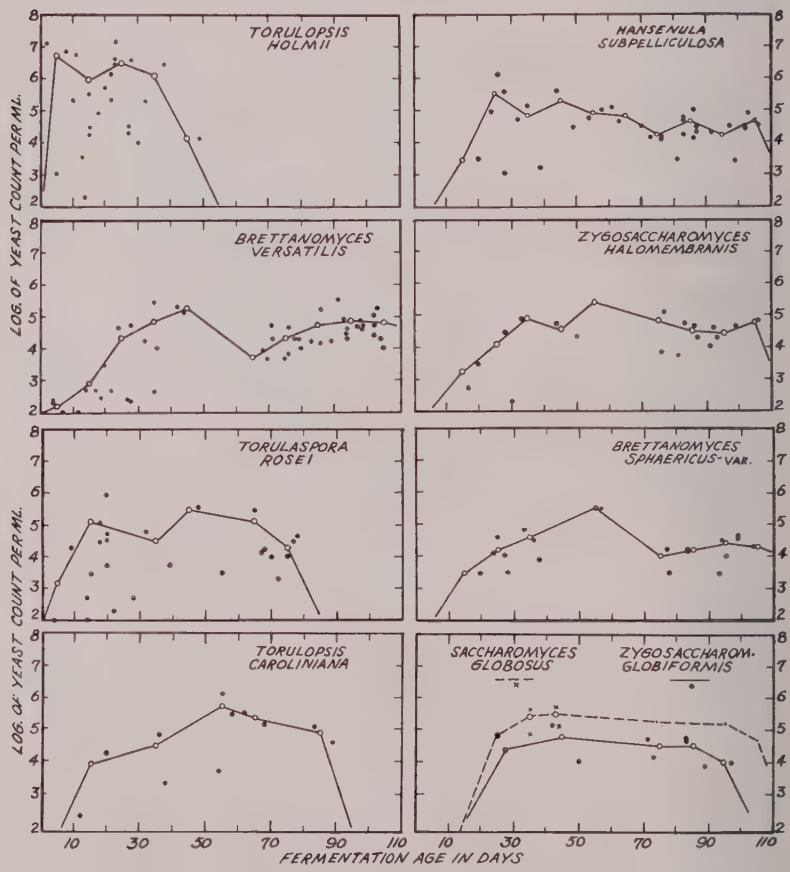

Figure 2. Population trends for nine species and one variety of six yeast genera occurring in cucumber fermentations brined under northern conditions.

in the current study on northern brines. It appears that *T. holmii* is the major species contributing to the early part of the northern fermentations, and *T. caroliniana* is of minor importance. *T. caroliniana* was found for a much longer period in northern than in southern brines; about 90 days versus 40 days. This is attributed, in part, to the fact that even though the former brines generally contain more total acid than the latter, they

also are more highly buffered and thus are not as toxic for *T. caroliniana* which is less acid tolerant than the other brine yeast species. Further, there is reason to believe that in some northern brines, *T. caroliniana* may have been missed because they grew out very poorly on the acidified glucose agar containing salt. Colonies which were about 0.1–0.2 mm. in diameter were first considered to be poorly developed lactobacilli colonies growing out, but later proved to be *T. caroliniana*. Upon transfer to less acid media, these cultures gave growth typical of the species. However, since all brines were first screened for the numbers and morphological types of live and dead yeast cells by the direct microscopic counting technique, it is doubtful if many isolates representing substantial populations of this species in brines were overlooked. *T. caroliniana*, because of its extremely small size, can usually be recognized in brine fermentations by microscopic examination.

Of the remaining three species (shown in figure 2), two, the unnamed variety of *Brettanomyces sphaericus* and *Saccharomyces globosus*, should be discussed briefly. The former species occurred in the brines during essentially the same period as did *B. versatilis* although not in as large numbers, or as consistently on a seasonal basis. Further, *B. sphaericus* var. was the only species, other than *B. versatilis*, that was found in brines after a 12–14 months' storage period. *S. globosus* occurred in several instances at rather widespread brining stations, and in rather high populations (400,000 to 500,000 per ml.). In a few cases it was found to be the principal yeast responsible for the vigorous gaseous fermentation that was observed when the brine samples were collected. Although this yeast species was obtained less frequently than most of the others, it cannot be omitted from important consideration as contributing to the gaseous fermentation in certain northern brines, ranging from 25 to over 100 days in age. As indicated before, the 50 unnamed isolates of *Zygosaccharomyces* (sp. A) obtained and described by Etchells and Bell (1950 *a*) from southern fermentations are considered to be the same as the 14 isolates placed as *Z. globiformis* in the present report. In both studies, this yeast represented about the same proportion of total isolations; 3.1 and 3.5 percent respectively for the northern and southern brine yeast studies.

Yeast Sequence in the Fermentation

A general picture as to yeast sequence in the fermentation of cucumbers under northern brining conditions based on the 3-year study is presented in figure 3. In the preparation of this diagram only data regarding five of the fermentative yeast species found in the brines were used. It is our opinion that these five yeasts were the principal species that contributed most consistently to the general yeast fermentation. The lesser species, *T. caroliniana*, *S. globosus*, *Z. globiformis*, *Z.* sp. A, *Z. pastori*, and the variety of *B. sphaericus* are not shown. *Candida krusei* and *Debaryomyces membranaefaciens* var. *Holl.* were excluded on the basis

that they were only very minor species, and because they probably originated during sampling from films on vat brines and thus were not a part of the subsurface yeast fermentation.

Influence of Room Temperature Incubation on Vat Brine Samples

During late October of the 1949 season, one quart samples of cucumbers and brine were collected by the plant chemist of one of the cooperating pickle plants from 21 vats located at six of their brining stations in Indiana, Michigan, and Wisconsin. These samples were incubated at room temperature in the control laboratory of the plant for about two weeks.

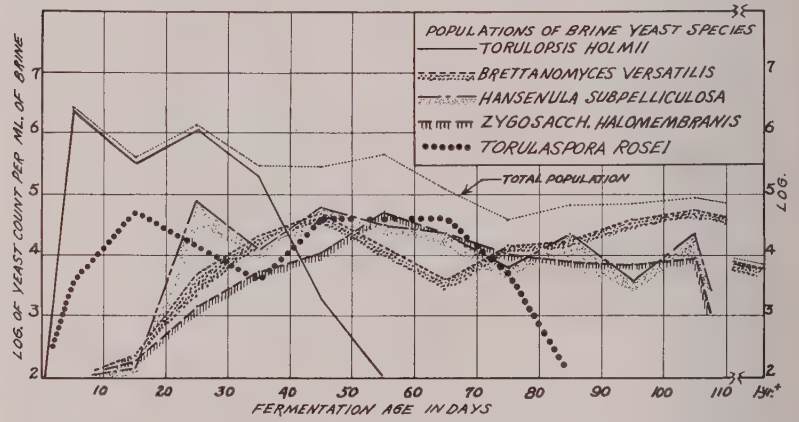

Figure 3. Yeast populations according to sequence of species in the fermentation of cucumbers brined under northern conditions.

Subsequent examination by us for the numbers and types of yeasts present is shown in table 4. Of the 55 isolates obtained, 40, or 73 percent, were *Brettanomyces versatilis*. This represents about a threefold increase in the numbers of this species compared to those obtained from brines in the same age group, but handled in the regular manner. Because of this very apparent difference in the numbers of *B. versatilis* present in the incubated brines, the 55 isolates, representing four yeast species, were not included in our results for the 1949 study. It is worth mentioning however, that five isolates of *T. rosei* were found in two of the incubated brines from one Wisconsin station. It will be recalled that this yeast was not found in the regular brines for 1949 and this was attributed in part to the fact that brining stations in Wisconsin were not visited during that season.

Pattern of Brine Yeast Species in Cucumber Fermentations

During the past five years the authors have isolated close to 1,900 yeast cultures from commercial cucumber fermentations. So far, the isolates directly related to the gaseous fermentation and subsequent storage period

TABLE 4. CLASSIFICATION OF 55 YEAST ISOLATES FROM 21 NORTHERN CUCUMBER BRINES WHICH WERE INCUBATED AT ROOM TEMPERATURE PRIOR TO EXAMINATION (1949 SEASON).

Brining Station (Code)	Vat No.	Age of Vat Brines	Chem. Exam. of Brines: Salt Conc. by Wt.	Chem. Exam. of Brines: Acidity as Lactic	Chem. Exam. of Brines: pH	Yeast Plate Count per ml. of Brine	Yeast Found and Number of Isolations: Brettanomyces *B. versatilis*	Brettanomyces *B. Sphaericus* var.	Hansenula *H. subpelliculosa*	Zygosacch. *Z. halomembranis*	Torulaspora *T. rosei*	Station Totals
		days	*percent*	*percent*		*in thous.*						
	10	71	...	...	...	28	3					
	12	71	13	0.63	3.6	...			2			
	19	77	12	.73	3.7	...	2					
	20	97	14	.54	3.7	400	2					
NJ	23	79	13	.75	3.6	140	3			2		(26)
	27	76	13	.68	3.6	...	1					
	28	76	13	.59	3.6	800	2					
	41	63	13	.66	3.8	68	3					
	43	69	14	.61	3.9	10	3					
	46	56	14	.50	4.0	710	3					
	6	76	13	0.56	3.8	260	2		1			
	26	73	13	.55	3.7	240	2					
KR	32	64	12	.52	3.6	...	2			1		
	35	57	13	.68	3.6	...		1	1			(16)
	41	79	13	.41	3.6	370	3					
	42	73	13	.32	3.8	160	2		1			
PL	27	69	...	...	...	12					2	(5)
	28	77	...	...	...	23					3	
CL	33	70	12	0.57	3.6	...	2					(2)
LA	23	76	12	0.58	3.6	28	3		1			(4)
BA	13	93	16	0.66	3.3	...	2					(2)
						Total	40	1	6	3	5	55
						% of Total	73	2	11	5	9	100%

have been classified into nine species and one variety of six genera. Based on the study of southern brines (Etchells and Bell, 1950 *a*) and on the current work, a probable pattern of brine yeast species (shown in table 5) has been prepared. From the work done to date, it becomes apparent that the pattern of species in brines from both northern and southern areas is very similar, although not necessarily identical. The occurrence of *S. globosus* in northern brines is the principal floral difference encountered to date. This overall pattern for yeasts in cucumber fermentations cer-

TABLE 5. PATTERN OF PRINCIPAL BRINE YEAST SPECIES IN COMMERCIAL CUCUMBER FERMENTATIONS.[1]

Species Found in Northern Brines	YEAST	Species Found in Southern Brines [2]
	BRETTANOMYCES	
+	*B. versatilis*	+
−	*B. sphaericus*	+
+	*B. sphaericus* var.	−
	TORULOPSIS	
+	*T. caroliniana*	+
+	*T. holmii*	+
	TORULASPORA	
+	*T. rosei*	+
	HANSENULA	
+	*H. subpelliculosa*	+
	ZYGOSACCHAROMYCES	
+	*Z. halomembranis*	+
+	*Z. globiformis*	+
	SACCHAROMYCES	
+	*S. globosus*	−

[1] Based on 1,896 isolates obtained from fermenting brines collected during five brining seasons (1946–50) from both northern and southern brining areas.

[2] Compiled from the study by Etchells and Bell (1950*a*).

tainly does not mean that additional species could not be found; the limiting factors for obtaining minor yeast species in cucumber fermentations has been discussed before (Cf. Etchells and Bell, 1950 *a*). Nor does it mean that certain species of *Candida, Debaryomyces, Rhodotorula*, and *Endomycopsis* will not occasionally be obtained from brines at the time cucumbers are brined (initial sampling), or in connection with the subsurface sampling of vats having luxuriant surface films.

SUMMARY

A study of the yeasts predominating during the fermentation of cucumbers under conditions typical of brining areas in Indiana, Michigan, and Wisconsin is presented. During three brining seasons (1948–50), 452 yeast isolates were obtained from 155 vat brines collected from 22 individual brining stations, operated by eight commercial pickle companies, in the above three states. Most of the isolations were made during a fermentation period of 2 to 105 days, although a few cultures came from vat brines that were 12 to 14 months old. During the period of observation the brines ranged from 4 to 18 percent salt by weight; 0.27 to 1.16 percent acid (calc. as lactic); and, 4.8 to 3.1 with respect to pH values.

The 452 yeast cultures were reduced to the following species listed in the order of frequency of isolation: *Brettanomyces versatilis* Etchells et Bell, 103 isolates (22.8%); *Torulaspora rosei* Guillermond, 68 (15.0%); *Torulopsis holmii* (Jörgensen) Lodder, 67 (14.8%); *Hansenula subpelliculosa* Bedford, 59 (13.1%); *Torulopsis caroliniana* Etchells et Bell, 36 (8.0%); *Brettanomyces sphaericus* var., 29 (6.4%); *Zygosaccharomyces halomembranis* Etchells et Bell, 28 (6.2%); *Saccharomyces globosus* Osterw., 22 (4.9%); *Zygosaccharomyces globiformis* Kr. et Kb., 14 (3.1%); *Candida krusei* (A. Cast.) Berkhout, 7 (1.5%); *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder, 5 (1.1%); *Zygosaccharomyces* sp. A, 3 (0.7%); *Zygosaccharomyces pastori* Guillermond, 1 (0.2%); and 10 (2.2%) isolates not fully classified. The presence of a few cultures of the film yeasts *C. krusei* and *D. membranaefaciens* var. *Holl.* was attributed to heavy surface film formation on the vat brines from which subsurface brine samples were obtained.

Results on the most likely sequence of yeasts occurring during the fermentation demonstrated that two species, *Torulopsis holmii* and *Brettanomyces versatilis,* were outstanding. The first yeast predominated during the early period of fermentation (2 to 30 days) and was followed by the second yeast which was most prevalent during the late stage of fermentation (70 to 110 days), but was still present in brines after 12 to 14 months' storage. Between the above two extremes in yeast sequence, the species *Torulaspora rosei, Hansenula subpelliculosa,* and *Zygosaccharomyces halomembranis* were active.

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